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# ECODRIVE03
# Drive For General Automation With Fieldbus-Interface

## Functional Description: FGP-03VRS

SYSTEM200

DOK-ECODR3-FGP-03VRS**-FK02-EN-P

Rexroth
Indramat

**Title** ECODRIVE03 Drive For General Automation With Fieldbus-Interface

**Type of Documentation** Functional Description: FGP-03VRS

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**Purpose of Documentation** The following documentation describes the functions of the firmware FWA-ECODR3-FGP-03VRS.

This documentation serves:

- for Description of all functional features

**Record of Revisions**

| Description | Release Date | Notes |
|---|---|---|
| DOK-ECODR3-FGP-03VRS**-FK02-EN-P | 02.00 | first release |
| | | |
| | | |

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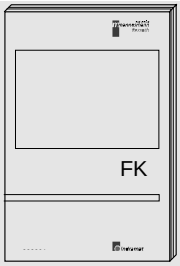
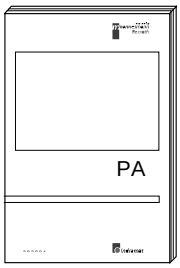
# Summary of Documentation - Box




Functional Description:

Description of all implemented Function based on SERCOS Parameters

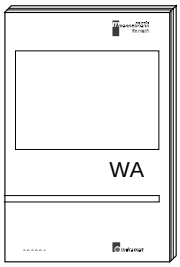
Order designation:
DOK-ECODR3-FGP-03VRS**-FK02-EN-P




Parameter Description:

A description of all parameters used in the firmware

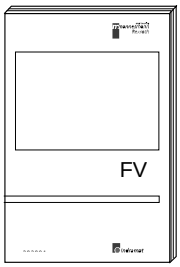
Order designation:
DOK-ECODR3-FGP-03VRS**-PA01-EN-P




Troubleshooting Guide:

-Explanation of the diagnostic states
-How to proceed when eliminating faults

Order designation:
DOK-ECODR3-FGP-03VRS**-WA01-EN-P

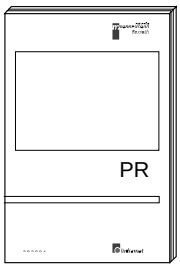



Firmware Version Notes:

Description of new and changed functions in terms of the derivatives:

-FWA-ECODR3-FGP-02VRS-MS

Order designation:
DOK-ECODR3-FGP-03VRS**-FV01-EN-P




Project Planning Manual:

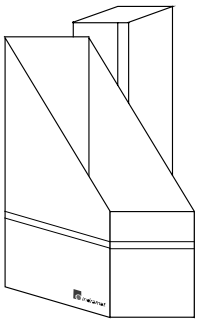
-Planning control cabinet construction
-Planning the electric layout in the control cabinet

Order designation:
DOK-ECODR3-DKC**.3****-PRxx-EN-P

CD: DRIVEHELP

Collection of Windows help systems which contain documents on firmware derivatives

Order designation:
DOK-GENERL-DRIVEHELP**-GExx-MS-D0600



Order designation
DOK-ECODR3-FGP-03VRS**-7302-EN-P

# Notes

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# 1 System Overview

## 1.1 ECODRIVE03 - the Universal Drive Solution for Automation

The universal automation system ECODRIVE03 is an especially cost-effective solution for drive and control tasks.

The servo drive system ECODRIVE03 features:

- a very broad implementation range
- extensively integrated functionalities
- a highly favorable price/performance ratio

Further features of **ECODRIVE03** are its easy assembly and installation, extreme machine accessing and the elimination of system components.

**ECODRIVE03** can be used to implement numerous drive tasks in the most varying of applications. Typical applications are:

- machine tools
- printing and paper processing machines
- handling systems
- packaging and food processing machines
- handling and assembly systems

## 1.2 ECODRIVE03 - a Drive Family

**FWA-ECODR3-FGP-0xVRS-MS** In addition to the here documented firmware FWA-ECODR3-FGP-03VRS-MS drive for general automation with fieldbus interfaces, there are also two additional application-related firmware variants.

**FWA-ECODR3-SMT-0xVRS-MS**

- drive for machine tool applications with SERCOS, analog and parallel interface

**FWA-ECODR3-SGP-0xVRS-MS**

- drive for general automation with SERCOS, analog and parallel interface

# 1.3 Drive Controllers and Motors

**Available controllers**

The drive controller family of the **ECODRIVE03** generation is at present made up of eight different units. These differentiate primarily in terms of which interface is used command communications.

- DKC01.3 Parallel interface
- DKC11.3 Analog interface
- DKC21.3 Parallel interface 2
- DKC02.3 SERCOS interface
- DKC03.3 Profibus-DP interface
- DKC04.3 InterBus interface
- DKC05.3 CANopen interface
- DKC06.3 DeviceNet interface

Each of these drive controllers is, in turn, available in a 40 A, 100 A or a 200 A version.

**Supported motor types**

With **ECODRIVE03** firmware it is possible to operate

- synchronous motors for standard applications up to 48 Nm.
- synchronous motors for increased demands of up to 64 Nm.
- asynchronous motors for main spindle applications
- asynchronous kit motors
- linear synchronous and asynchronous motors

# 1.4 Function Overview: FWA-ECODR3-FGP-03VRS-MS

## Command Communications Interface

- Profibus-DP interface
- CANopen interface
- InterBus interface
- Analog interface
- DeviceNet interface

## Supported Profile Types

- I/O mode with block acknowledge (functionally compatible with DKC3.1)
- I/O mode with cam status
- I/O mode free expandable + expandable real time data channel
- drive-internal interpolation
- cyclical position control
- velocity control
- free configurable mode (without profile interpreter)

## Supported Types of Motors

- MKD
- 2AD
- 1MB
- LAF
- MKE
- MBS
- MHD
- ADF
- MBW
- LAR
- LSF

## Supported Measuring Systems

- HSF/LSF
- resolver
- sine encoder with 1Vss signals
- encoder with EnDat-Interface
- resolver without feedback data memory
- resolver without feedback data memory with incremental sine encoder
- gearwheel encoder with 1Vss signals
- Hall encoder + square-wave encoder
- Hall encoder + sine encoder

Which combination is possible, is outlined in section: "Setting the Measurement System"

# Firmware Functions

- Extensive diagnostics options
- Basic parameter block that can be activated for a defined setting of the drive parameters to default values.
- Customer passwords
- List of password-protected data
- Error memory and operating hour counter
- Supports five (5) languages for parameter names and units and diagnoses (S-0-0095)
  - German
  - English
  - French
  - Spanish
  - Italian
- Settable drive-internal position resolution
- Evaluation of option (load-side) encoder for position and/or velocity control
- Evaluates absolute measuring system with setting of absolute dimension
- Modulo function
- Parametrizable torque limit
- Current limit
- Velocity limit
- Travel range limit:
  - via travel range limit switch and/or
  - position limit values
- Drive-side error reactions:
  - error reaction "return limit"
  - best possible standstill "velocity command to zero"
  - best possible standstill "Torque free"
  - best possible standstill "velocity command to zero with ramp and filter
  - power shutdown with fault
  - NC reaction with fault
  - E-Stop function
- Control loop settings
  - base load function
  - acceleration precontrol
  - velocity mix factor
  - velocity precontrol
  - automatic control loop settings
- Velocity control loop monitor
- Position control loop monitor
- Drive halt

- Command "Drive-controlled homing"
- Command "Set Absolute Measuring"
- Analog output
- Analog input
- Oscilloscope function
- Probe function
- Command "Parking Axis"
- Command "Detect marker position"
- Command "Positive stop drive procedure"
- Command "Measuring wheel operation mode"
- Dynamic cam switch group
- Encoder emulation
  - absolute encoder emulation (SSI format)
  - incremental encoder emulation

# 2 Important directions for use

## 2.1 Introduction

Rexroth Indramat products represent state-of-the-art developments and manufacturing. They are tested prior to delivery to ensure operating safety and reliability.

The products may only be used in the manner that is defined as appropriate. If they are used in an inappropriate manner, then situations can develop that may lead to property damage or injury to personnel.

**Note:** Rexroth Indramat, as manufacturer, is not liable for any damages resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forfeited. The user alone carries all responsibility of the risks.

Before using Rexroth Indramat products, make sure that all the pre-requisites for an appropriate use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with appropriate use.
- If the product takes the form of hardware, then they must remain in their original state, in other words, no structural changes are permitted. It is not permitted to decompile software products or alter source codes.
- Do not mount damaged or faulty products or use them in operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

## 2.2 Inappropriate use

The use of the firmware and the drive controllers outside of applications other than specified in the system overview or under operating conditions other than those specified in the project planning manual and not with the use of the specified technical data is defined as “inappropriate use”.

Drive controllers may not be used if

- they are subject to operating conditions that do not meet the above specified ambient conditions. This includes, for example, operation under water, in the case of extreme temperature fluctuations or extremely high maximum temperatures or if
- Rexroth Indramat has not specifically released them for that intended purpose. Please note the specifications outlined in the general safety instructions!

# 3 Safety Instructions for Electric Servo Drives and Controls

## 3.1 Introduction

Read these instructions before the equipment is used and eliminate the risk of personal injury or property damage. Follow these safety instructions at all times.

Do not attempt to install, use or service this equipment without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation of the equipment prior to working with the equipment at any time. If you do not have the user documentation for your equipment contact your local Rexroth Indramat representative to send this documentation immediately to the person or persons responsible for the safe operation of this equipment.

If the product is resold, rented or transferred or passed on to others, then these safety instructions must be delivered with the product.

**WARNING**

**Inappropriate use of this equipment, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, may result in product damage, personal injury, severe electrical shock or death!**

## 3.2 Explanations

The safety warnings in this documentation describe individual degrees of hazard seriousness in compliance with ANSI:

| **Warning symbol with signal word** | **Degree of hazard seriousness**<br>The degree of hazard seriousness describes the consequences resulting from non-compliance with the safety guidelines. |
|---|---|
| <br>**DANGER** | Bodily harm or product damage will occur. |
| <br>**WARNING** | Death or severe bodily harm may occur. |
| <br>**CAUTION** | Death or severe bodily harm may occur. |

Fig. 3-1: Classes of danger with ANSI

## 3.3 Hazards by inappropriate use

**DANGER**

**High voltage and high discharge current! Danger to life, risk of severe electrical shock and risk of injury!**

**DANGER**

**Dangerous movements! Danger to life and risk of injury or equipment damage by unintentional motor movements!**

**WARNING**

**High electrical voltage due to wrong connections! Danger to life, severe electrical shock and severe bodily injury!**

**WARNING**

**Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!**

**CAUTION**

**Surface of machine housing could be extremely hot! Danger of injury! Danger of burns!**

**CAUTION**

**Risk of injury due to inappropriate handling! Bodily injury caused by crushing, shearing, cutting and mechanical shock or improper handling of pressurized systems!**

**CAUTION**

**Risk of injury due to inappropriate handling of batteries!**

# 3.4 General Information

- Rexroth Indramat GmbH is not liable for damages resulting from failure to observe the warnings given in these documentation.
- Order operating, maintenance and safety instructions in your language before starting up the machine. If you find that due to a translation error you can not completely understand the documentation for your product, please ask your supplier to clarify.
- Proper and correct transport, storage, assembly and installation as well as care in operation and maintenance are prerequisites for optimal and safe operation of this equipment.
- Trained and qualified personnel in electrical equipment:
  Only trained and qualified personnel may work on this equipment or within its proximity. Personnel are qualified if they have sufficient knowledge of the assembly, installation and operation of the product as well as an understanding of all warnings and precautionary measures noted in these instructions.
  Furthermore, they should be trained, instructed and qualified to switch electrical circuits and equipment on and off, to ground them and to mark them according to the requirements of safe work practices and common sense. They must have adequate safety equipment and be trained in first aid.
- Only use spare parts and accessories approved by the manufacturer.
- Follow all safety regulations and requirements for the specific application as practiced in the country of use.
- The equipment is designed for installation on commercial machinery.

European countries: see directive 89/392/EEC (machine guideline).

- The ambient conditions given in the product documentation must be observed.
- Use only safety features that are clearly and explicitly approved in the Project Planning manual.
  For example, the following areas of use are not allowed: Construction cranes, Elevators used for people or freight, Devices and vehicles to transport people, Medical applications, Refinery plants, the transport of hazardous goods, Radioactive or nuclear applications, Applications sensitive to high frequency, mining, food processing, Control of protection equipment (also in a machine).
- Start-up is only permitted once it is sure that the machine, in which the product is installed, complies with the requirements of national safety regulations and safety specifications of the application.
- Operation is only permitted if the national EMC regulations for the application are met.
  The instructions for installation in accordance with EMC requirements can be found in the INDRAMAT document "EMC in Drive and Control Systems”.
  The machine builder is responsible for compliance with the limiting values as prescribed in the national regulations and specific EMC regulations for the application.

European countries: see Directive 89/336/EEC (EMC Guideline).

U.S.A.: See National Electrical Codes (NEC), National Electrical Manufacturers Association (NEMA), and local building codes. The user of this equipment must consult the above noted items at all times.

- Technical data, connections and operational conditions are specified in the product documentation and must be followed at all times.

# 3.5 Protection against contact with electrical parts

**Note:** This section refers to equipment with voltages above 50 Volts.

Making contact with parts conducting voltages above 50 Volts could be dangerous to personnel and cause an electrical shock. When operating electrical equipment, it is unavoidable that some parts of the unit conduct dangerous voltages.

**DANGER**

**High electrical voltage! Danger to life, severe electrical shock and severe bodily injury!**

⇒ Only those trained and qualified to work with or on electrical equipment are permitted to operate, maintain or repair this equipment.

⇒ Follow general construction and safety regulations when working on electrical installations.

⇒ Before switching on power the ground wire must be permanently connected to all electrical units according to the connection diagram.

⇒ Do not operate electrical equipment at any time if the ground wire is not permanently connected, even for brief measurements or tests.

⇒ Before working with electrical parts with voltage potentials higher than 50 V, the equipment must be disconnected from the mains voltage or power supply.

⇒ The following should be observed with electrical drives, power supplies, and filter components:

Wait five (5) minutes after switching off power to allow capacitors to discharge before beginning work. Measure the voltage on the capacitors before beginning work to make sure that the equipment is safe to touch.

⇒ Never touch the electrical connection points of a component while power is turned on.

⇒ Install the covers and guards provided with the equipment properly before switching the equipment on. Prevent contact with live parts at any time.

⇒ A residual-current-operated protective device (r.c.d.) must not be used on an electric drive! Indirect contact must be prevented by other means, for example, by an overcurrent protective device.

⇒ Equipment that is built into machines must be secured against direct contact. Use appropriate housings, for example a control cabinet.

European countries: according to EN 50178/1998, section 5.3.2.3.

U.S.A: See National Electrical Codes (NEC), National Electrical Manufacturers Association (NEMA) and local building codes. The user of this equipment must observe the above noted instructions at all times.

To be observed with electrical drives, power supplies, and filter components:

**DANGER**

**High electrical voltage! High leakage current! Danger to life, danger of injury and bodily harm from electrical shock!**

⇒ Before switching on power for electrical units, all housings and motors must be permanently grounded according to the connection diagram. This applies even for brief tests.

⇒ Leakage current exceeds 3.5 mA. Therefore the electrical equipment and units must always be firmly connected to the supply network.

⇒ Use a copper conductor with at least 10 mm² cross section over its entire course for this protective connection!

⇒ Prior to startups, even for brief tests, always connect the protective conductor or connect with ground wire. High voltage levels can occur on the housing that could lead to severe electrical shock and personal injury.

European countries: EN 50178/1998, section 5.3.2.1.

USA: See National Electrical Codes (NEC), National Electrical Manufacturers Association (NEMA), and local building codes. The user of this equipment must maintain the above noted instructions at all times.

## 3.6 Protection by protective low voltage (PELV) against electrical shock

All connections and terminals with voltages between 5 and 50 Volts on INDRAMAT products are protective low voltages designed in accordance with the following standards on contact safety:

- International: IEC 364-4-411.1.5
- EU countries: see EN 50178/1998, section 5.2.8.1.

**WARNING**

**High electrical voltage due to wrong connections! Danger to life, severe electrical shock and severe bodily injury!**

⇒ Only equipment, electrical components and cables of the protective low voltage type (PELV = Protective Extra Low Voltage) may be connected to all terminals and clamps with 0 to 50 Volts.

⇒ Only safely isolated voltages and electrical circuits may be connected. Safe isolation is achieved, for example, with an isolating transformer, an opto-electronic coupler or when battery-operated.

## 3.7 Protection against dangerous movements

Dangerous movements can be caused by faulty control or the connected motors. These causes are be various such as:

- unclean or wrong wiring of cable connections
- inappropriate or wrong operation of equipment
- malfunction of sensors, encoders and monitoring circuits
- defective components
- software errors

Dangerous movements can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

The monitors in the drive components make faulty operation almost impossible. Regarding personnel safety, especially the danger of bodily harm and property damage, this alone should not be relied upon to ensure complete safety. Until the built-in monitors become active and effective, it must be assumed in any case that some faulty drive movements will occur. The extent of these faulty drive movements depends upon the type of control and the state of operation.

**DANGER**

**Dangerous movements! Danger to life and risk of injury or equipment damage!**

⇒ Personnel protection must be secured for the above listed reason by means of superordinate monitors or measures.

These are instituted in accordance with the specific situation of the facility and a danger and fault analysis conducted by the manufacturer of the facility. All the safety regulations that apply to this facility are included therein. By switching off, circumventing or if safety devices have simply not been activated, then random machine movements or other types of faults can occur.

**Avoiding accidents, injury or property damage:**

⇒ Keep free and clear of the machine's range of motion and moving parts. Prevent people from accidentally entering the machine's range of movement:

- use protective fences
- use protective railings
- install protective coverings
- install light curtains or light barriers

⇒ Fences must be strong enough to withstand maximum possible momentum.

⇒ Mount the emergency stop switch (E-stop) in the immediate reach of the operator. Verify that the emergency stop works before startup. Don't operate the machine if the emergency stop is not working.

⇒ Isolate the drive power connection by means of an emergency stop circuit or use a start-inhibit system to prevent unintentional start-up.

⇒ Make sure that the drives are brought to standstill before accessing or entering the danger zone.

⇒ Secure vertical axes against falling or slipping after switching off the motor power by, for example:

- Mechanically securing the vertical axes
- Adding an external brake / clamping mechanism
- Balancing and thus compensating for the vertical axes mass and the gravitational force

The standard equipment motor brake or an external brake controlled directly by the servo drive are not sufficient to guarantee the safety of personnel!

⇒ Disconnect electrical power to the equipment using a master switch and secure the switch against reconnection for:

- maintenance and repair work
- cleaning of equipment
- long periods of discontinued equipment use

⇒ Avoid operating high-frequency, remote control and radio equipment near electronics circuits and supply leads. If use of such equipment cannot be avoided, verify the system and the plant for possible malfunctions at all possible positions of normal use before the first start-up. If necessary, perform a special electromagnetic compatibility (EMC) test on the plant.

## 3.8 Protection against magnetic and electromagnetic fields during operations and mounting

Magnetic and electromagnetic fields generated by current-carrying conductors and permanent magnets in motors represent a serious health hazard to persons with heart pacemakers, metal implants and hearing aids.

**WARNING**

**Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!**

⇒ Persons with pacemakers, metal implants and hearing aids are not permitted to enter following areas:

- Areas in which electrical equipment and parts are mounted, being operated or started up.
- Areas in which parts of motors with permanent magnets are being stored, operated, repaired or mounted.

⇒ If it is necessary for a person with a pacemaker to enter such an area, then a physician must be consulted prior to doing so. Pacemaker, that are already implanted or will be implanted in the future, have a considerable deviation in their resistance to interference. Due to the unpredictable behavior there are no rules with general validity.

⇒ Persons with hearing aids, metal implants or metal pieces must consult a doctor before they enter the areas described above. Otherwise health hazards will occur.

## 3.9 Protection against contact with hot parts

**CAUTION**

**Housing surfaces could be extremely hot!**
**Danger of injury! Danger of burns!**

⇒ Do not touch surfaces near the source of heat! Danger of burns!

⇒ Wait ten (10) minutes before you access any hot unit. Allow the unit to cool down.

⇒ Do not touch hot parts of the equipment, such as housings, heatsinks or resistors. Danger of burns!

## 3.10 Protection during handling and installation

Under certain conditions unappropriate handling and installation of parts and components may cause injuries.

**CAUTION**

**Risk of injury through incorrect handling!**
**Bodily harm caused by crushing, shearing, cutting and mechanical shock!**

⇒ Observe general instructions and safety regulations during handling installation.

⇒ Use only appropriate lifting or moving equipment.

⇒ Take precautions to avoid pinching and crushing.

⇒ Use only appropriate tools. If specified by the product documentation, special tools must be used.

⇒ Use lifting devices and tools correctly and safely.

⇒ Wear appropriate protective clothing, e.g. safety glasses, safety shoes and safety gloves.

⇒ Never stay under suspended loads.

⇒ Clean up liquids from the floor immediately to prevent personnel from slipping.

## 3.11 Battery safety

Batteries contain reactive chemicals in a solid housing. Inappropriate handling may result in injuries or equipment damage.

**CAUTION**

**Risk of injury through incorrect handling!**

⇒ Do not attempt to reactivate discharged batteries by heating or other methods (danger of explosion and corrosion).

⇒ Never charge batteries (danger from leakage and explosion).

⇒ Never throw batteries into a fire.

⇒ Do not dismantle batteries.

⇒ Handle with care. Incorrect extraction or installation of a battery can damage equipment.

**Note:** Environmental protection and disposal! The batteries contained in the product should be considered as hazardous material for land, air and sea transport in the sense of the legal requirements (danger of explosion). Dispose batteries separately from other refuse. Observe the legal requirements given in the country of installation.

## 3.12 Protection against pressurized Systems

Certain Motors (ADS, ADM, 1MB etc.) and drives, corresponding to the information in the Project Planning manual, must be provided with and remain under a forced load such as compressed air, hydraulic oil, cooling fluid or coolant. In these cases, improper handling of the supply of the pressurized systems or connections of the fluid or air under pressure can lead to injuries or accidents.

**CAUTION**

**Danger of injury when pressurized systems are handled by untrained personnel!**

⇒ Do not attempt to disassemble, to open or to cut a pressurized system.

⇒ Observe the operation restrictions of the respective manufacturer.

⇒ Before the disassembly of pressurized systems, lower pressure and drain off the fluid or gas.

⇒ Use suitable protective clothing (for example protective eyewear, safety shoes and gloves)

⇒ Remove any fluid that has leaked out onto the floor immediately.

**Note:** Environmental protection and disposal! The fluids used in the operation of the pressurized system equipment is not environmentally compatible. Fluid that is damaging to the environment must be disposed of separate from normal waste. Observe the national specifications of the country of installation.

# 4 General Instructions for Installation

## 4.1 Definition of Terms, Introduction

It is helpful to explain the terms used in this document so that they will be better understood.

### Parameter

Communication with the drive occurs (with a few exceptions) with the help of parameters. They can be used for

- Setting the configuration
- parametrizing the control/drive settings
- Accessing control/drive functions and commands
- Cyclical or acyclical (depending on requirements) transmission of command and actual values

**Note:** All of the drive's operating data are identified by ID numbers.

**The Data Status**

Each parameter is provided with a data status, which can also be read. It serves the following purposes:

- Identifying the validity/invalidity of the parameter
- Contains the command acknowledgement if the parameter acts as a command

(see also Commands)

**Parameter structure**

There are seven different data block elements for each parameter. These can be read/write accessed either via a user data interface by a higher-ranking control or a parametrization surface.

| Element No.: | Designation: | Remarks: |
|---|---|---|
| 1 | ID Number | Parameter identification |
| 2 | Name | can be changed in language selection |
| 3 | Attribute | contains data length, type and decimal places |
| 4 | Unit | can be changed in language selection |
| 5 | Minimum Input Value | contains the minimum input value of the operating data |
| 6 | Maximum Input Value | contains the maximum input value of the operating data |
| 7 | Operating Data | actual parameter value |

Fig. 4-1: Data blocks or parameter structure

**Write Accessibility**

Only the operating data can be changed; all other elements can only be read.

The operating data can be write-protected either continuously or temporarily.

The write accessing of the operating data depends on the relevant communications phase.

### Possible Error Messages when Reading and Writing Operating Data

| Error: | Reason: |
|---|---|
| 0x7002, data transmitted too short | Less bytes than the parameter is long are sent to the drive |
| 0x7003, data transmitted too long | More bytes than the parameter is long are sent to the drive |
| 0x7004, Data not changeable | The operating data is write-protected |
| 0x7005, Data currently write-protected | The operating data cannot be written to in this communication phase (see Supplement A: Parameter description) |
| 0x7006, Data smaller than minimum value | The operating data is smaller than its minimal input value |
| 0x7007, Data larger than maximum value | The operating data is larger than its maximum input value |
| 0x7008, Data is not correct | The value could not be accepted as written because internal tests lead to a negative result |
| 0x7009, data write protected with password | The parameter cannot be write accessed as the customer password was activated in parameter **S-0-0267, Password**. All parameters listed in S-0-0192, IDN-list of backup operation data are therefore locked. |

Fig. 4-2: Error messages while reading/writing operating data

## Data Storage

### Non-volatile Parameter Storage Registers

Various non-volatile parameter storage registers that buffer operating data are contained in the drive.

The operating data apply to:

- setting the configuration or
- parametrizing the control drive settings

Each time operating data is written to it is stored.

The following modules contain non-volatile memory:

- Control drive
- Motor feedback (optional)
- Programming module

**Parameters Stored in the Digital Drive**

All operating data that apply only to the drive controller and that cannot be changed by the user are stored in the digital drive.

This consists of the following parameters:

- **S-0-0110, Amplifier peak current**
- **S-0-0140, Controller type**
- **P-0-0190, Operating hours control section**
- **P-0-0191, Operating hours power section**
- **P-0-0192, Error recorder, diagnosis number**
- **P-0-0193, Error recorder, operating hours control section**
- **P-0-0520, Hardware code**
- **P-0-4000, Current-zero-trim phase U**
- **P-0-4001, Current-zero-trim phase V**
- **P-0-4002, Current-amplify-trim phase U**
- **P-0-4003, Current-amplify-trim phase V**
- **P-0-4024, Test status**
- **P-0-4035, Trim-current**
- **P-0-4053, Intermediate DC bus voltage gain adjust**
- **P-0-4054, Resolver input offset**
- **P-0-4055, Resolver input, amplitude adjust**
- **P-0-4058, Amplifier type data**
- **P-0-4059, Braking resistor data**
- **P-0-4061, Mains voltage gain adjust**
- **P-0-4088, Serial number**
- **P-0-4089, Production index**

## Parameter Storage in Motor Feedback

All motor-dependent parameters are stored in the motor feedback with MHD, MKD and MKE motors.

Additionally, parameters for the "Load Default" function and the position encoder are stored here.

All parameters stored in the motor feedback data memory are there with both parameter block number 0 and 7.

In parameter block number 7 (e.g., S-7-0100) the original data without write access are stored in the motor feedback data memory. These are copied after powering up into the parameters of parameter block number 0 (e.g., S-0-0100). Parameter block with number 0 is stored in the programming module.

**Note:** The parameters of parameter block number 0 take effect.

**Parameters Stored in DSM Programming Module**

All application parameters are stored in the programming module (control loop, mechanical system, interface parameters and so on).

All ID numbers backed up in this module are listed in parameter **S-0-0192, IDN-list of backup operation data**.

If the programming module is exchanged then these application parameters must be read out before hand so that they can be written into the new module after the exchange.

---

**Note:** By switching the programming module when devices are exchanged, the characteristics (firmware and parameter) of the device that has been exchanged can be easily transferred to the new device.

---

## Data Saving

**Back-up & Restore-**

To save the data of the axis, all important and changeable parameters of the axis are stored in the list **S-0-0192, IDN-List of backup operation data**. By saving the parameters listed there with the control or parametrization surface, you can obtain a complete data backup of this axis after the first set-up (Back-up & restore function).

---

**Note:** Parameter **S-0-0269, Parameter buffer mode** is insignificant as of version FGP-02VRS as all the parameters are backed up from that point on in a NOVRAM.

---

## Basic parameter block

The drive parameters are fixed at delivery at the factory. By executing the command **P-0-4094, C800 Command Base-parameter load** it is possible to reproduce this state at any time. The basic parameter block is constructed so that

- all optional drive functions are deactivated
- limit values for position are deactivated
- limit values for torque/force are set to high values
- and limit values for velocity and acceleration are set to lower values

Velocity control is the mode set.

---

**Note:** The basic parameter block does not guarantee a matching of the drive to the machine as well as, in some cases, to the motor connected and the measuring systems. The relevant settings must be made when first starting up the axis.

---

(See also: "Basic Drive Functions" and "Commissioning Guidelines".)

### Running the "load basic parameter block" function automatically

The drive firmware is on the programming module. In the event of a firmware exchange (with a different number of buffered parameters), the drive controller will detect this the next time the machine is switched on. In this case, the message "**PL**" appears on the 7-segment display. By pressing the "**S1**" key, the basic parameter block is activated.

**Note:** Any previous parameter settings are lost with the replacement of the firmware followed by "load base parameter block". If this is to be prevented, then the parameters must be stored prior to an exchange and must be reloaded after exchange and load base parameter block.

**Note:** As long as the drive displays "PL" and the command is active, then communications via the serial interface (with DriveTop) is not possible.

## Password

The affected parameters are stored in **S-0-0279, IDN-list of password-protected operation data.** To secure these parameters against unwanted or non-authorized changes, the customer password can be activated.

By editing **S-0-0279, IDN-list of password-protected operation data** the user can select the parameter which are to be protected with a password.

**Note:** **The default value of S-0-0279, IDN-list of password-protected operation data** corresponds to the contents of **S-0-0192, IDN-list of backup operation data**.

**Accessing the password**

The password is accessed with parameter **S-0-0267, Password**.

**Allowable symbols and length**

The password has to have:

- at least 3 symbols
- no more than ten symbols
- can only use the letters a - z and A - Z
- and the numbers 0 to 9.

**3 different password states are possible**

The password function can have three different states. Depending on the sequence of symbols entered for **S-0-0267** the current password status can be changed.

The following illustrates possible password states and the symbol sequence for parameter **S-0-0267**.

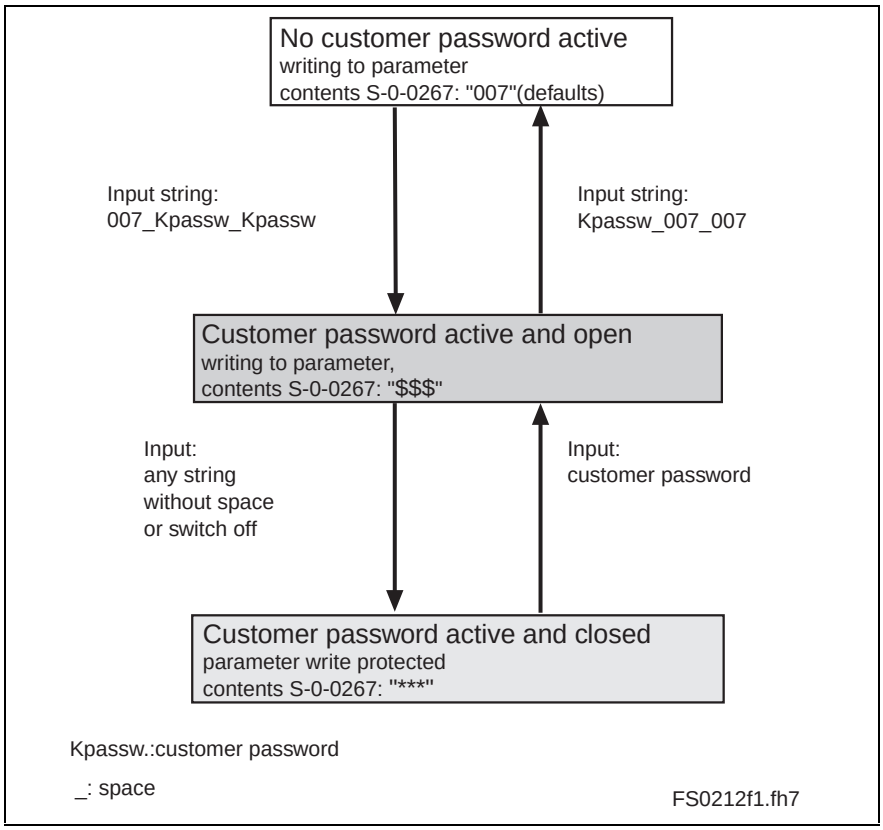


Fig. 4-3: Possible password states

**Note:** **If the user's password is activated and unlocked (content of** S-0-0267= "$$$"), then the drive is locked after switching the machine off (contents of S-0-0267= "***").

**Note:** As long as the drive displays "PL" and the command is active, then communications via the serial interface (with DriveTop) is not possible.

**Master password**

Rexroth Indramat retains the rights to the master password function.

## Commands

Commands are used to control complex functions in the drive. For example, the functions "Drive-Controlled Homing Procedure" or "Transition Check for Communication Phase 4" are defined as commands.

**Each command that is started must also be cleared.**

A primary control can start, interrupt or erase a command.

Each command has a parameter with which the command can be controlled.

While a command is being executed, the diagnostic message "Cx" or "dx" appears in the H1 display, where x is the number of the command.

**list of all procedure commands**

All commands used are stored in parameter **S-0-0025, IDN-list of all procedure commands.**

## Command Types

There are 3 command types.

- **Drive-Controlled Command**
  - Eventually leads to an automatic drive operation or motion
  - Can be started only when controller enable is set
  - Deactivates the active operating mode during its operation
- **Monitor Command**
  - Activates or deactivates monitors or features in the control drive
- **Management Command**
  - executes management tasks; is not interruptable

## Command Input and Acknowledgement

Control and monitoring of command execution occurs via the command input and command acknowledgement. The command input tells the drive if the command should be started, interrupted or ended. The commanded value is the operating data of the applicable parameter. The command input value can be:

- not set and not enabled (0)
- interrupted (1)
- set and enabled (3)

In the acknowledgement, the drive informs about the extent to which a command has been executed. This is then displayed in the data status of the command parameter.

See also capter: "Parameter".

**Note:** The command status can be obtained by conducting a write error on parameter element 1 (data status).

**data status**

The condition can be:

- not set and not enabled (0)
- in process (7)
- error, command execution not possible (0xF)
- command execution interrupted (5)
- command properly executed (3)

**Change Bit Command**

The Change Bit Command in the Drive Status Word helps the control recognize a change in the command acknowledgement by the drive. The bit is set by the drive if the command acknowledgement changes from the condition in process (7) to the condition error, command execution not possible (0xF) or command properly executed (3). The bit is cleared if the master clears the input (0).

The control system will recognize if the drive sets the Command Change Bit command. It can read the corresponding data status of the command or the command itself, which was set sometime but has not been cleared. The control system will recognize from this if the command ended with or without an error in the drive. Afterwards this command should be cleared by the control.

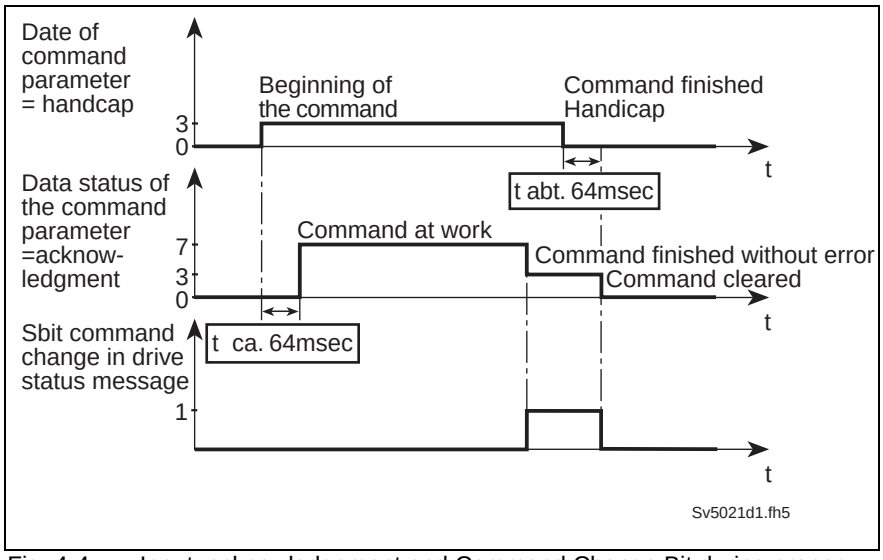


Fig. 4-4: Input, acknowledgement and Command Change Bit during proper execution

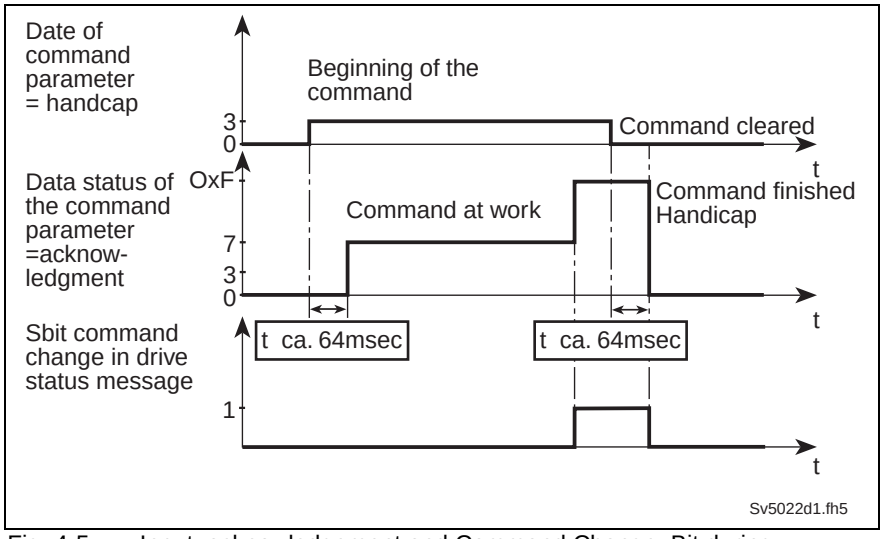


Fig. 4-5: Input, acknowledgement and Command Change Bit during erroneous execution

A delay time of up to 64ms can occur in the drive between receiving the command input and setting the command acknowledgement.

## Operating Modes

Operating modes define which command values will be processed in which format, leading to the desired drive motion. They do not define how these command values will be transmitted from a control system to the drive.

One of the four selectable operating modes (S-0-0032…S-0-0035) is active when:

- the control and power supply is ready for operation and the controller enable signal is positive.
- The drive displays **"AF"** in the H1 display.

---

**Note:** All implemented operating modes are stored in parameter **S-0-0292, List of all operation modes**.

---

See also chapter: "Operating Modes"

# Warnings

**Warnings do not cause automatic shutdowns Exception: fatal wanings**

Many areas are monitored in connection with operating modes and parameter settings. A warning will be generated if a state is detected that allows proper operation for the time being, but will eventually generate an error and thereby lead to a shutdown of the drive if this state continues.

## Warning Classes

**The warning class is evident from the diagnostic message**

Warnings can be separated into 2 classes. They are differentiated by whether the drive executes an automatic reaction when the warning appears.

| Warning Class: | Diagnostic Message: | Drive Response: |
|---|---|---|
| With drive response | E8xx | reacts on its own specifically in terms of any occurring warnings |
| Without drive response | E2xx | -- |

Fig. 4-6: Breakdown of the Warning Classes

**Note:** Warnings cannot be cleared externally. They pend until the conditions that lead to the warning are no longer present.

# Error

Many areas are monitored in connection with operating modes and parameter settings. An error message is generated if a condition is encountered which no longer allows proper operation

## Error Classes

Errors are separated into four different drive's error response. The error class is evident from the diagnostic message:

| Error Class: | Diagnostic Message: | Drive Response: |
|---|---|---|
| Fatal | F8xx | Torque free switching |
| Travel range | F6xx | Velocity command value switched to zero |
| Interface | F4xx | In accordance with best possible deceleration |
| Non-fatal | F2xx | In accordance with best possible deceleration |

Fig. 4-7: Error class divisions

## Drive's Error Response

If an error state is detected in the drive, the drive's error response will automatically be executed as long as the drive is in control. The H1 display flashes Fx / xx. The drive's reaction to interface and non-fatal errors can be parameterized with **P-0-0119, Best possible deceleration**. The drive switches to torque-free operation at the end of each error reaction.

### Clearing Errors

Errors are not automatically cleared; they are cleared externally by:

- Initiating the command **S-0-0099, C500 Reset class 1 diagnostic** or
- pressing the "S1" key or
- positiv edge at the input "clear error".

If the error state is still present, then the error will be immediately detected again.

### Clearing Errors When Controller Enable Is Set

If an error is discovered while operating with set controller enable, the drive will execute an error response. The drive automatically deactivates itself at the end of each error response; in other words, the power stage is switched off and the drive switches from an energized to a de-energized state.

To reactivate the drive:

- clear the error

  AND
- enter a 0-1 edge bit into the controller enable

---

**Note:** In fieldbus drives the state machine must first be initialised.

---

**Error memory**

### Error memory and operating hour counter

Once errors are cleared, they are stored in an error memory. The last 19 errors are stored there and the times they occurred.

Errors caused by a shutdown of the control voltage (e.g., **F870 +24Volt DC error** ) are not stored in the error memory.

**operating hour**

Simultaneously, there is an operating hour counter for control and power sections of the drive controller. This function has the following parameters:

- **P-0-0190, Operating hours control section**
- **P-0-0191, Operating hours power section**
- **P-0-0192, Error recorder diagnosis number**
- **P-0-0193, Error recorder, operating hours control section**

## IDN List of Parameters

There are parameters in the drive that, in turn, contain ID numbers of drive parameters. These support the handling of the drive parameters with parametrization programs (e.g., DriveTop).

### S-0-0017, IDN-list of all operation data

The ID numbers of all parameters in the drive are in this parameter. This list supports, for example, the parametrization program in the menu of which "All drive parameters" the information as to which ID number is in this drive firmware is stored.

## S-0-0192, IDN-list of backup operation data

In parameter **S-0-0192, IDN-list of backup operation data** the ID numbers of all those parameters are stored, that are stored in the programming module. These are the parameters that are needed for a proper operation of the drive. The control or the parametrization program uses this ID number list to secure a copy of the drive parameters.

## S-0-0021, IDN-list of invalid op. data for comm. Ph. 2

In the data of these ID lists, the drive enters the ID numbers out of parameter **S-0-0018, IDN-list of operation data for CP2** which are recognized as invalid in command **S-0-0127, C100 Communication phase 3 transition check**. Parameters are recognized as invalid if:

- their checksums, that are stored together with the operating data in a resident memory (programming module, amplifier or motor feedback data memory), do not fit to the operating data,
- their operating data is outside of the minimum/maximum input range or
- their operating data has violated the plausibility rules.

In any event, the parameters entered upon negative acknowledgement of command **S-0-0127, C100 Communication phase 3 transition check** in **S-0-0021, IDN-list of invalid op. data for comm. Ph. 2** must be corrected.

## S-0-0022, IDN-list of invalid op. data for comm. Ph. 3

The drive enters the ID numbers out of parameter **S-0-0019, IDN-list of operation data for CP3** into the data of this ID list, which were detected in command **S-0-0128, C200 Communication phase 4 transition check** as invalid. Parameters are detected as invalid if:

- their checksum, stored together with the operating data in a resident memory (programming module, amplifier or motor feedback data memory) do not match the operating data,
- their operating data are outside of the minimum/maximum input limits or
- their operating data has violated the plausibility rules.

In any event, the parameters entered upon negative acknowledgement of command **S-0-0128, C100 Communication phase 4 transition check** in **S-0-0022, IDN-list of invalid op. data for comm. Ph. 3** must be corrected.

## S-0-0018, IDN-list of operation data for CP2

The ID numbers that were checked for validity in command **S-0-0127, C100 Communication phase 3 transition check** are stored in **S-0-0018, IDN-list of operation data for CP2**.

## S-0-0019, IDN-list of operation data for CP3

The ID numbers that were checked for validity in command **S-0-0128, C200 Communication phase 4 transition check** are stored in **S-0-0019, IDN-list of operation data for CP3**.

## S-0-0025, IDN-list of all procedure commands

The ID numbers of all the commands in the drive are stored in this parameter.

# 4.2 Parametrization Mode - Operating Mode

**Note:** A drive controller with fieldbus interface immediately switches into operating mode when switched on.

The switch from parametrization to operating mode is controlled by start and end commands

- **S-0-0127, C100 Communication phase 3 transition check**
- **S-0-0128, C200 Communication phase 4 transition check**
- **P-0-4023, C400 Communication phase 2 transition**

It is necessary to trigger the transition command **P-0-4023, C400 Communication phase 2 transition** to get into parametrization mode.

**Note:** In order to be able to switch between the parametrization mode and operating mode, it is only possible to start a transition command, if the drive is not in control mode or command communications is not active.

The current status of command communications is in parameter **P-0-4086, Command communication status**.

If the drive reaches phase 4 without an error, then the message (H1) "**bb**" appears on the 7-segment display on the front of the drive amplifier. The corresponding diagnosis is: **A013 Ready for power on**

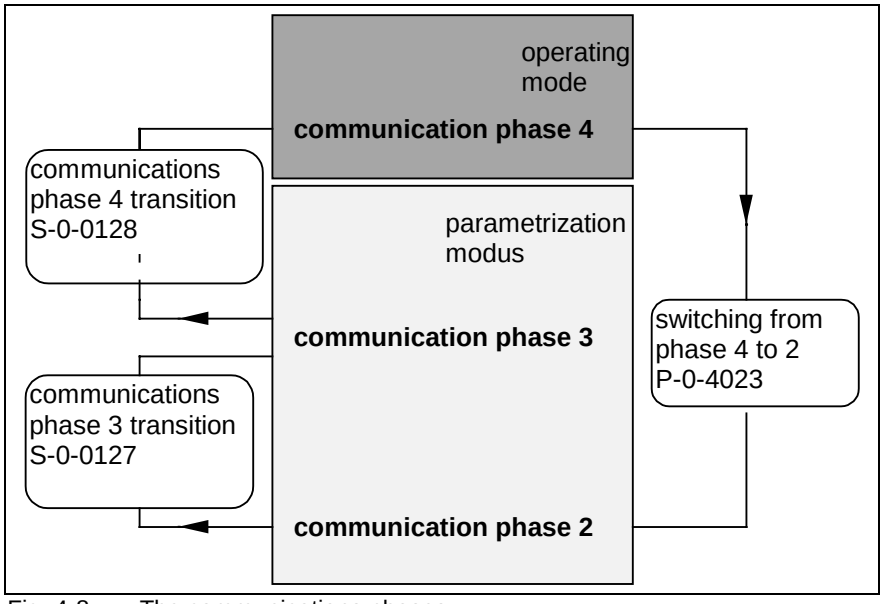


Fig. 4-8: The communications phases

**Note:** The evaluation of the measuring systems as well as the processing of the encoder emulation's only takes place in operating mode. Switching from operating mode into parametrization mode means that these functions are no longer active. The switch into operating mode always starts a new initialization of all the functions within the drive.

# Checks in the Transition Commands

To switch from communication phases 2 to 3 and 3 to 4, it is necessary to activate transition checks in the drive first. This includes a number of checks and parameter conversions.

**Note:** The reasons for and assistance with transition command errors are specified in the diagnostics description.

## S-0-0127, C100 Communication phase 3 transition check

The timing of command communications is checked in transition command C1. These checks are irrelevant for those units without command communications. (Examples of command communications are SERCOS, Profibus and so on.)

The following checks are conducted in the C1 command.

**Checking the telegram configuration of the command communications**

This checks as to whether the parameters selected for the configurable data block in the master data telegram or drive data telegram may be configured or not. It also checks whether the allowable length of the configurable data blocks has been retained or not.

The following command errors can occur, in this case: :

- **C104 Config. IDN for MDT not configurable**
- **C105 Configurated length > max. length for MDT**
- **C106 Config. IDN for AT not configurable**
- **C107 Configurated length > max. length for AT**

**Checking validity of communications parameters**

If the checksum of one of the parameters needed to progress into phase 3 is faulty, then command error:

- **C101 Invalid communication parameter (S-0-0021)**

is generated. The ID no. of the faulty parameters are listed in:

- **S-0-0021, IDN-list of invalid op. data for comm. phase 2**

They are made valid by writing into them.

**Extreme value check of the communications parameters**

If an error occurs during the extreme value check of those parameters relevant to the command communications, then command error

- **C102 Limit error communication parameter (S-0-0021)**

is generated. The ID numbers of the faulty parameters are listed in

- **S-0-0021, IDN-list of invalid op. data for comm. phase 2**

and must then be corrected.

**Checking plausibility and maintaining the marginal conditions for command communications**

Checking the timing parameters for command communications in terms of plausibility and maintaining marginal conditions.

The following command errors can occur:

- **C112 TNcyc (S-0-0001) or TScyc (S-0-0002) error**
- **C113 Relation TNcyc (S-0-0001) to TScyc (S-0-0002) error**
- **C114 T4 > TScyc (S-0-0002) - T4min (S-0-0005)**

## S-0-0128, C200 Communication phase 4 transition check

During this command, the following checks are run.

**Checking P-0-4014 for plausibility**

If in parameter **P-0-4014, Motor type** 1 (MHD) or 5 (MKD/MKE) are selected and the motor feedback data memory has not found that type, then command error

- **C204 Motor type P-0-4014 incorrect**

is generated.

**Checking validity**

If the checksum of one of the parameters needed to progress into phase 4 is faulty, then command error:

- **C201 Invalid parameter(s) (->S-0-0022)**

is generated. The ID number of the faulty parameters are listed in

- **S-0-0022, IDN list of invalid op. data for comm. phase 3**

and are made valid by writing into.

**Reading the controller memory**

The drive controller reads the non-volatile memory, e.g., EEPROM, of the drive controller operating data. If an error occurs during this process, then command error:

- **C212 Invalid amplifier data (->S-0-0022)** appears**.**

The ID number of the faulty parameter is written in

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3.**

**Checking whether optional encoder is needed**

If operating mode parameters **S-0-0032..35** or referencing parameter **S-0-0147** bit3 dictates that a second encoder is required but a "0" is entered in parameter **P-0-0075, Feedback type 2** then the faulty parameter(s) is listed in:

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3**

Command error

- **C210 Feedback 2 required (->S-0-0022)** appears.

**Checking whether motor encoder is available**

Check whether a motor encoder is available (**P-0-0074, Feedback type 1** = 0) and no "2" is entered in function parameter **P-0-0185, Function of encoder 2** for load-side motor encoder. If this is the case, then command error

- **C236 Feedback 1 required (P-0-0074)**

is generated.

**Checking motor encoder settings**

If the encoder parametrized in parameter **P-0-0074, Feedback type 1** is not available, or its data cannot be read, then this error message is generated

- **C217 Feedback1 data reading error**

**Checking optional encoder settings**

If the encoder interface selected in parameter **P-0-0075, Feedback type 2** is already occupied by the motor encoder, then this error message is generated:

- **C234 Encoder combination not possible**

generated.

If a second encoder with feedback data memory is used but its data cannot be read, then error message

- **C218 error when reading data of encoder 2**

is generated. If parameter **P-0-0185, Function Encoder 2** "load-side motor encoder" is selected, but there is no rotary asynchronous motor, then error message

- **C235 Load-side motor encoder only with asynchronous motor**

is generated.

**Reading out feedback data memory**

The parameters stored in the memory of motors with feedback data memory are read. If an error occurs during this process, then command error

- **C211 Invalid feedback data (->S-0-0022)** is generated.

**Checking maximum travel range**

Check whether an internal position resolution has been set via parameter **S-0-0278, Maximum travel range** which guarantees the correct commutation of the motor. If not, then this command error appears:

- **C223 Input value for max. range too high.**

**Checking scaling**

Check internal ability to illustrate conversion factors from display format to an internal one and vice versa for scaling-dependent data. If an error occurs, then one of the following command errors can be generated:

- **C213 Position data scaling error**
- **C214 Velocity data scaling error**
- **C215 Acceleration data scaling error**
- **C216 Torque/force data scaling error**

**Checking all parameters for extreme values and possible bit combinations**

All parameters are checked for maintaining extreme values or permissible bit combinations. If an error occurs, then command error

- **C202 Parameter limit error (->S-0-0022)**

is generated. The ID number o the faulty parameter is listed in

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3**

and must be corrected.

**Checking modulo range**

Checking whether an activated modulo scaling of the position from parameter **S-0-0103, Modulo value** is possible. If it is not, then command error

- **C227 Modulo range error**

is generated.

**Checking the conversion of internal formats**

The physical values of parameters (input format with decimal places and units) are converted to internal formats. This conversion is monitored. If incongruencies are detected during this process, then command error

- **C203 Parameter calculation error (->S-0-0022)**

is generated. The ID number of the faulty parameter is listed in

- **S-0-0022, IDN-list of invalid op. data for comm. phase 3**

and must be corrected.

**Checking encoder initialization**

Encoder initialization is listed. Errors can occur depending on encoder type (e.g., index length wrong in DSF feedback). Then one of the following command error

- **C220 Feedback 1 initializing error**
- **C221 Feedback 2 initializing error**

is generated.

**Absolute encoder monitoring**

If the actual position of an absolute encoder is outside of the range of the current actual position prior to the last shutdown, +/- **P-0-0097, Absolute encoder monitoring window,** then error

- **F276 Absolute encoder outside of monitoring window**

is generated. The acknowledgement of the transition command is not faulty in this case but rather the error must be cleared by executing command **S-0-0099, C500 Reset class 1 diagnostics**.

(Also see section: "Clearing Errors").

# 4.3 Commissioning Guidelines

For commissioning drive controllers, the parametrization interface DriveTop can be used.

The procedures for commissioning a drive controller with DriveTop entail 11 steps (IBS-1..11).

The sequence is illustrated below.

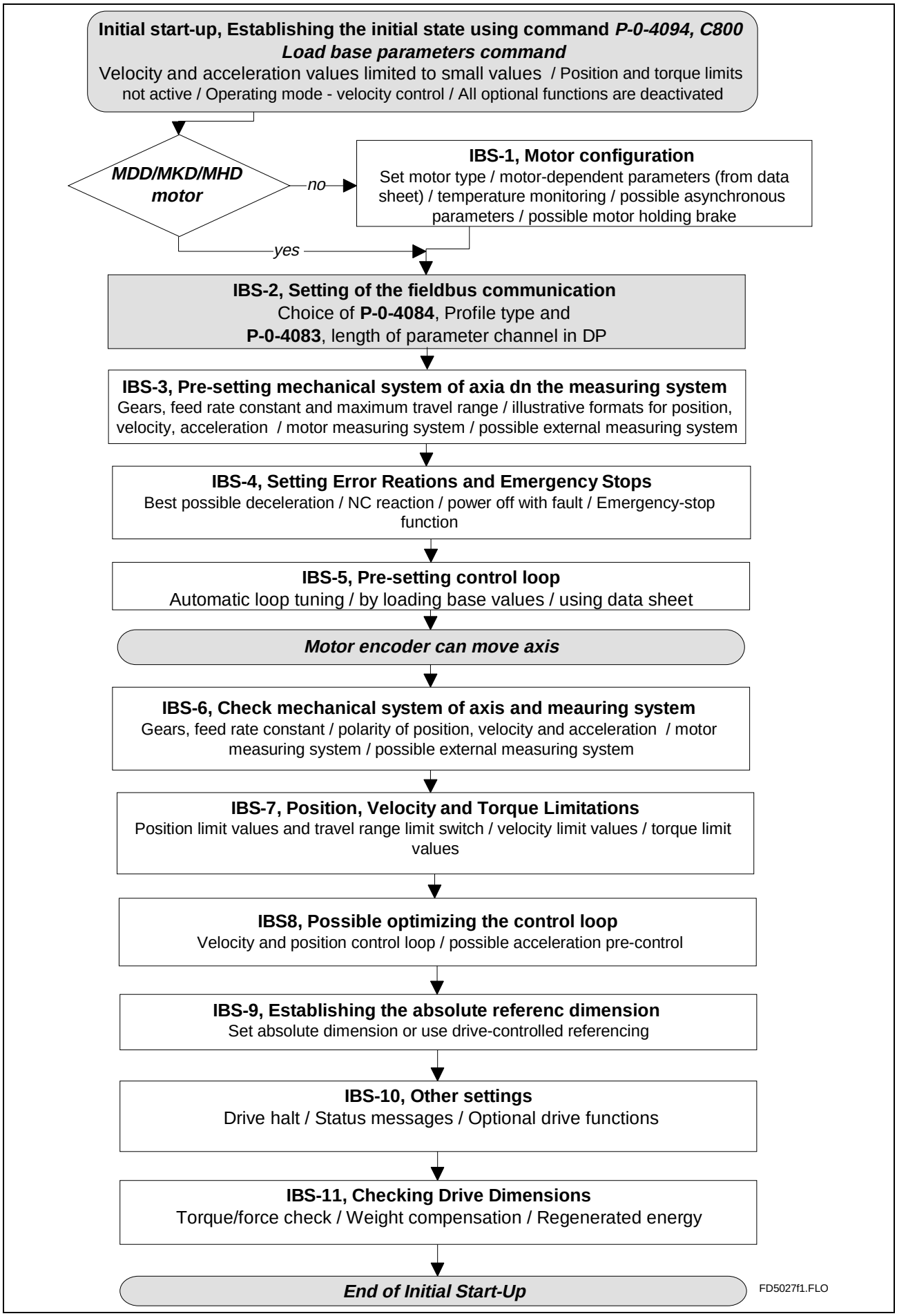
Initial start-up, Establishing the initial state using command P-0-4094, C800
Load base parameters command
Velocity and acceleration values limited to small values / Position and torque limits not active / Operating mode - velocity control / All optional functions are deactivated
MDD/MKD/MHD motor
no
IBS-1, Motor configuration
Set motor type / motor-dependent parameters (from data sheet) / temperature monitoring / possible asynchronous parameters / possible motor holding brake
yes
IBS-2, Setting of the fieldbus communication
Choice of P-0-4084, Profile type and
P-0-4083, length of parameter channel in DP
IBS-3, Pre-setting mechanical system of axia dn the measuring system
Gears, feed rate constant and maximum travel range / illustrative formats for position, velocity, acceleration / motor measuring system / possible external measuring system
IBS-4, Setting Error Reations and Emergency Stops
Best possible deceleration / NC reaction / power off with fault / Emergency-stop function
IBS-5, Pre-setting control loop
Automatic loop tuning / by loading base values / using data sheet
Motor encoder can move axis
IBS-6, Check mechanical system of axis and meauring system
Gears, feed rate constant / polarity of position, velocity and acceleration / motor measuring system / possible external measuring system
IBS-7, Position, Velocity and Torque Limitations
Position limit values and travel range limit switch / velocity limit values / torque limit values
IBS8, Possible optimizing the control loop
Velocity and position control loop / possible acceleration pre-control
IBS-9, Establishing the absolute referenc dimension
Set absolute dimension or use drive-controlled referencing
IBS-10, Other settings
Drive halt / Status messages / Optional drive functions
IBS-11, Checking Drive Dimensions
Torque/force check / Weight compensation / Regenerated energy
End of Initial Start-Up
FD5027f1.FLO

Fig. 4-9:Commissioning guidelines

## IBS-1, Motor configuration

**motor without data memory**

These guidelines are needed in the case where the motor used does not have a motor feedback memory. It is necessary with these motors to enter:

- the parameters for motor features (peak current, maximum velocity, etc.) using the data sheet or with DriveTop using data from the motor data bank.
- the parameters for the motor temperature warning and off thresholds must be parametrized as well
- and given a motor holding brake, these parameters must be properly set also.

**motor with data memory**

Those motors with data memory such as

- MHD, MKD,MKE-motors

are recognized by the drive and motor parameters are automatically set.

(See also chapter: "Setting the Motor Type".)

## IBS-2, Setting up fieldbus communication

**P-0-4084, Profile type** must be set up in this step to be able to select the operating mode wanted and its relevant profile interpreter (including status machine).

To ensure the functioning of the related modes (S-0-0032 to S-0-0035), the following is necessary:

- operating mode-specific settings (e.g., positioning block data in positioning block mode)
- mode-relevant limit value settings
- command value filter settings that may be necessary
- definition of the operating modes available.

---

**Note:** In the case of command communications using a Profibus it is also possible in this step to define a parameter channel in the real time channel **P-0-4083, Length of parameter channel**. For CANbus it is necessary to also set the **P-0-4079, Fieldbus baudrate** here.

---

(See also section: "Profile Types".)

## IBS-3, Presetting the axis mechanics and measuring systems

In this step, the parameters needed for determining and processing position, velocity and acceleration data are set. These include the following parameters for the following settings:

- mechanical gear ratio between motor and load as well as any existing feedrate constants of the drive of linear slides
- scaling settings for showing position, velocity and acceleration parameters of the drive. This sets, for example, whether the data is motor shaft or load related and which LSB valence these have, e.g., position data with 0.001 degrees or 0.0001 inches and so on.
- Interfaces, rotational directions and the resoluton of the motor encoder, and where available, optional encoders.

(See also chapter : -"Physical Values Display Format"mat"
-"Mechanical Transmission Elements" and
-"Setting the Measurement System").

## IBS-4, Setting the error reactions and E-stop

In this step, the reaction of the drive in the event of an error is set as well as the triggering of the drive's own E-stop input. The following parametrizations must be performed:

- type and mode of error reactions in drive
- selection whether NC reaction in error case should happen
- selection whether and if so when, the power supply is switched off and whether a package reaction is to be conducted
- Configuration of the E-stop input

(See also chapter: "Drive Error Reaction")

## IBS-5, Pre-setting Control Loop

The parameters for current, velocity and position control loops are set in this step. This is done either by:

- Execute command **P-0-0162, D900 Command Automatic control loop adjust**
  During the execution of the command, the setting for the velocity controller and the position controller is determined as well as the load inertia.

or

- Execute command **S-0-0262, C700 Command basic load** or
- by inputting the controller values specified in the data sheet.

Setting the control loop in this way ensures a good level of quality for most applications. Should additional optimization of the control loop parameters become necessary (velocity and position control loop parameters, compensation functions and precontrol), then use commissioning step no. 8.

(See also chapter: "Control Loop Settings".)

## IBS-6, Checking axis mechanics and measuring system

The presettings made in IBS 3 are checked here and modified, if necessary. This means that the axis must be moved by jogging. The following checks must be made:

- check the rotational direction of the motor encoder. With non-inverted position polarity (**S-0-0055, Position polarities** = 0), the values in parameter **S-0-0051, Position feedback 1 value** should have a rising order with a clockwise rotation of the motor. (This check need not be performed in MHD and MKD motors. If this is not the case, then bit 2 in **S-0-0277, Position feedback 1 type** must be inverted.
- By moving the axes and examining the position feedback value of the motor encoder in parameter **S-0-0051, Position feedback 1 value** it can be checked whether a distance is correctly displayed in this process. If not, then the settings for mechanical gear ratio, feedrate constants and encoder resolution must be checked.

- Given a second encoder, by moving the axis and examining the position feedback value of the external encoder in parameter **S-0-0053, Position feedback 2 value** it can be checked whether a distance is correctly displayed in this process. **S-0-0051, Position feedback 1 value** and **S-0-0053, Position feedback 2 value** should run parallel when jogging a specific path. If not, then check the settings in **P-0-0075, Feedback type 2, S-0-0117, Feedback 2 Resolution, S-0-0115, Position feedback 2 type** and **P-0-0185, Function of encoder 2.**

(See also chapter : -"Physical Values Display Format"
-"Mechanical Transmission Elements" and
-"Setting the Measurement System").

## IBS-7, Limits for position, velocity and torque

The limits for the travel range are conducted by setting

- position limits values and/or
- travel range limit switches

as well as the limit values for the axis velocity and maximum drive torque/force are parametrized also.

(See also chapter: -"Torque Limit",
-"Travel Range Limits" and
-"Limiting Velocity".)

## IBS-8, Optimizing the control loop

This step is only necessary if the settings for velocity and position control loops in IBS 4 did not achieve the needed quality. As such, optimize the control behavior as follows:

- modify the parameter for velocity and position control loops
- possibly activate the acceleration pre-control
- possibly activate the velocity mixture and
- possibly activate the notch filter.

(See also chapter: "Control Loop Settings".)

## IBS-9, Establishing absolute reference measuring

Here the absolute reference measuring is set in terms of the machine zero point of the position feedback value from motor encoder and possibly optional encoder. At first the position feedback values show any value, not machine zero point related values. By conducting

- setting absolute measuring (with absolute encoders) or
- drive-controlled homing

the coordinate systems of the position encoder and the coordinate system of the machine are made congruent.

(See also chapter: -"Drive-Controlled Homing" and
-"Setting the Absolute Dimension")

## IBS-10, Other settings

Here

- drive halt function is parametrized,
- the language selected,
- general status message settings and
- the optional drive function settings are conducted.

(See also chapter: -"Drive Halt"
-"S-0-0013, Class 3 diagnostics"
-"S-0-0182, Manufacturer class 3 diagnostics"
-"Optional Drive Functions"
-"Language Selection"

## IBS-11,Controlling drive dimensions

The power-related drive checks are conducted here. It is checked whether the continuous and peak power of drive amplifier and motor meet the requirements. The following checks are conducted for this purpose:

- generated torque/force of motor is checked. At a constant speed 60% and in rapid traverse 75% of the continuous torque at standstill of the motor should not be exceeded
- during the acceleration phase 80% of the maximum torque of the motor/controller combination may not be exceeded
- the thermal load of the drive amplifier should equal a maximum of 80%

(See also chapter: "Current Limit")

With vertical axis, the weight compensation must be set so that the current consumption with upwards and downwards motions of the axes have the same minimum value.

Check the regenerated peak power and regenerated continuous power.

# 4.4 Diagnostic Configurations

## Overview of Diagnostic Configurations

The diagnostics are configured into 2 groups:

- options for recognizing the current operating states of the priority-dependent, drive-internal generation of diagnoses
- collective messages for diverse status messages

Additionally, there are parameters for all important operating data that can be transmitted both via the command communications (SERCOS, Profibus, ...) as well as the parametrization interface (RS-232/485 in the ASCII protocol or SIS serial Rexroth Indramat protocol).

## Drive-Internal Diagnostics

The current operating condition of the drive depends on:

- any present errors
- any present warnings
- commands executed
- the signal "Drive Halt"
- the execution of an error reaction
- the automatic drive check or self-adjustment
- the active operating mode

Whether the drive is in preparation for operation or in parameter mode also is displayed.

The current operating condition can be determined from

- the 2-part seven-segment display (H1 display)
- the diagnostic parameter **S-0-0095, Diagnostic Message**
- the parameter **S-0-0390, Diagnostic Message Number**
- the parameter **P-0-0009, Error Message Number**
- the parameter **S-0-0375, List of diagnostic numbers**

The current diagnostic message with the highest priority is always shown in the

- H1 display,
- **S-0-0095, Diagnostic Message** and
- **S-0-0390, Diagnostic Message Number**.

The parameter **P-0-0009, Error Message Number** will contain a value unequal to 0 if an error is present.

The last displayed diagnostic numbers are displayed in chronological order in parameter **S-0-0375, List of diagnostic numbers**.

An overview of all diagnostic messages can be found in the diagnostic description (Troubleshooting Guide).

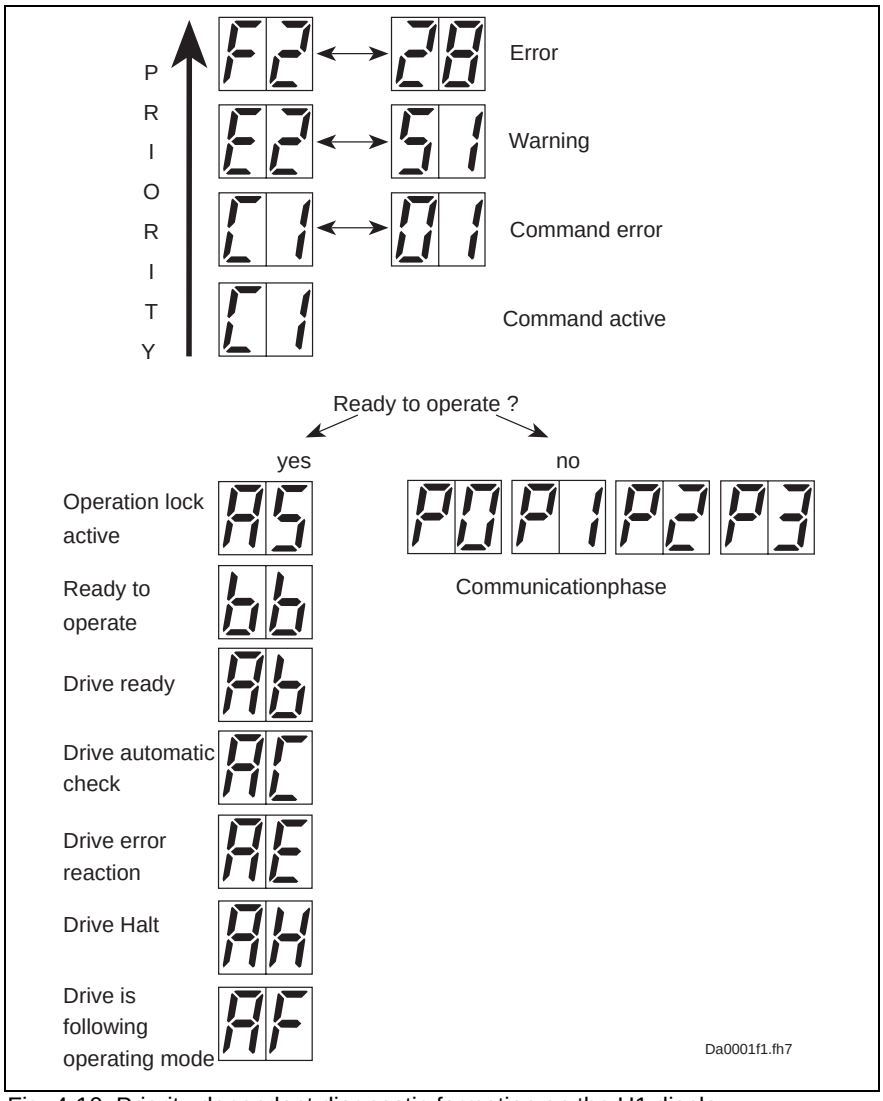


Fig. 4-10: Priority-dependent diagnostic formation on the H1 display

## Diagnostic Message Composition

Each operating condition is designated with a diagnostic message, which consists of a

- diagnostic message number and a
- diagnostic text

For example, the diagnostic message for the non-fatal error "Excessive Control Deviation" is displayed as follows.

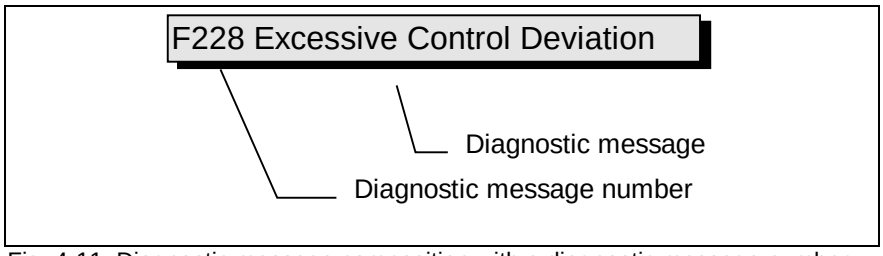


Fig. 4-11: Diagnostic message composition with a diagnostic message number and text

The H1 display alternates "F2" and "28". The diagnostic message number appears in hexadecimal format in the parameter **S-0-0390, Diagnostic Message Number**. In this example, this would be (0x)F228. The diagnostic message number and the diagnostic text are contained as a string **F228 Excessive deviation** in the parameter **S-0-0095, Diagnostic Message**. The parameter **P-0-009, Error message number** contains 228 (dec).

## H1-Display

The diagnostic number appears on the two-part seven-segment display. The form of the display emerges from the graphic "Priority-Dependent Display of the Diagnostic Message".

With the help of this display, it is possible to quickly determine the current operating status without using a communication interface.

The operating mode cannot be seen on the H1-Display.

If the drive follows the operating mode and no command was activated, then the symbol AF appears on the display.

## Diagnostic Message

The diagnostic message contains the diagnostic number followed by the diagnostic text, as shown in the example, Excessive Control Deviation. It can be read with the parameter **S-0-0095, Diagnostic Message** and directly displays the operation status on an operator interface.

The diagnostic message language can be changed.

## Diagnostic Message Number

The diagnostic message number contains only the diagnostic number without the text. It can be read with the parameter **S-0-0390, Diagnostic Message Number**.

## Error Number

The error number contains only the error number without the diagnostic text. It can be read with the parameter **P-0-0009, Error Message Number** and can indicate an error condition without a language barrier. This parameter contains a value unequal to 0 if an error is present in the drive.

An error is formed from the bottom 3 digits of the diagnostic number. For example, the error **F228 Excessive deviation** with the diagnostic message number "(0x)F228" would produce the error number "228."

## List of diagnostic numbers

The 50 previously displayed diagnostic numbers are displayed in chronological order in parameter **S-0-0375, List of diagnostic numbers**. Every change in contents of **S-0-0390, Diagnostic message number** means that the old contents are transferred into **S-0-0375, List of diagnostic numbers**. If **S-0-0375, List of diagnostic numbers** is read, then the last replaced diagnostic number appears in the first element; the diagnostic number displayed penultimately is displayed in the second element and so on.

The following illustration explains the relationship between **S-0-0375, List of diagnostic numbers** and **S-0-0390, Diagnostic message number** with the use of an example.

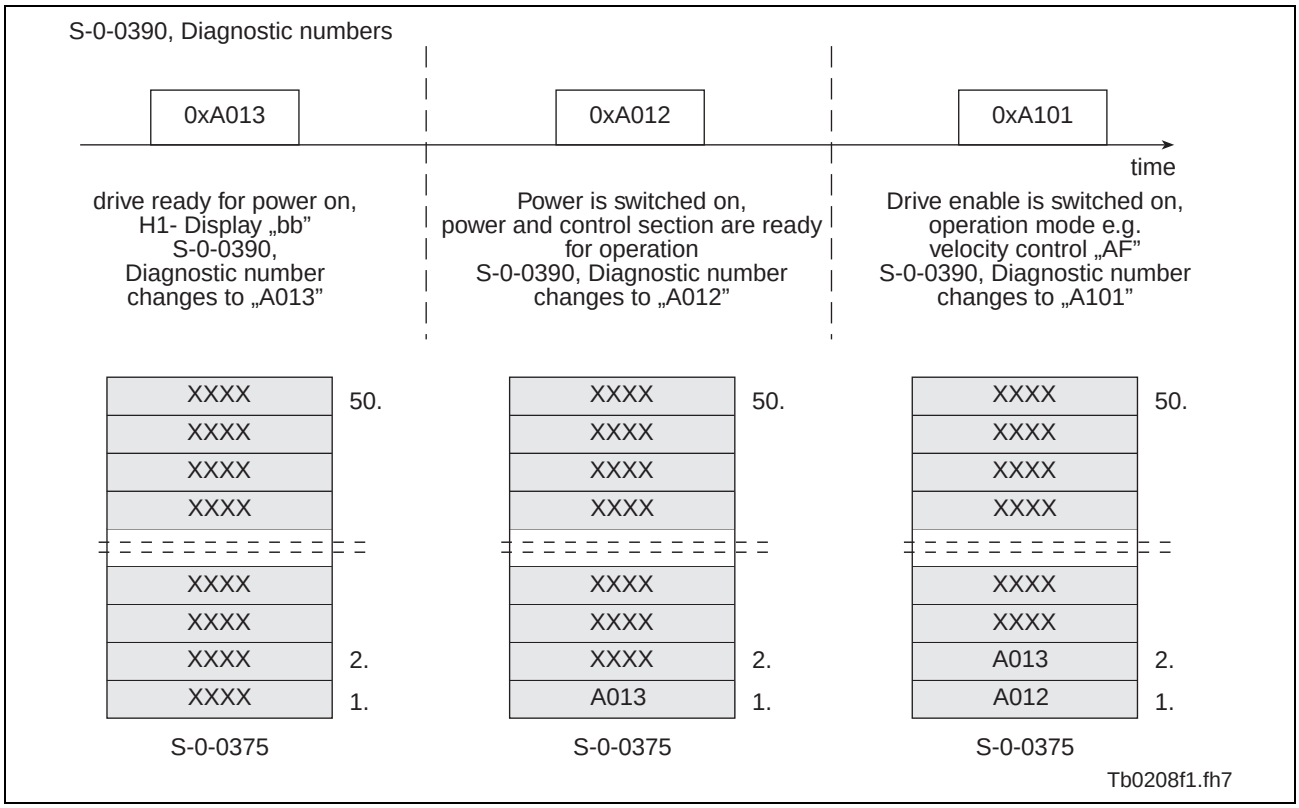
S-0-0390, Diagnostic numbers
0xA013
0xA012
0xA101
time
drive ready for power on, H1- Display „bb” S-0-0390, Diagnostic number changes to „A013”
Power is switched on, power and control section are ready for operation S-0-0390, Diagnostic number changes to „A012”
Drive enable is switched on, operation mode e.g. velocity control „AF” S-0-0390, Diagnostic number changes to „A101”
XXXX
50.
2.
1.
A013
A012
S-0-0375
Tb0208f1.fh7

Fig. 4-12: Example for generating **S-0-0375, List of diagnostic numbers**

## Permanently-Configured Collective Indication

There are parameters that represent a collective indication for the display of operating states. These are individually listed

- **S-0-0011, Class 1 diagnostics**
- **S-0-0012, Class 2 diagnostics**
- **S-0-0013, Class 3 diagnostics**
- **S-0-0182, Manufacturer class 3 diagnostics**

### S-0-0011, Class 1 diagnostics

In parameter **S-0-0011, Class 1 diagnostics** there are bits for the various errors. A bit is set in this parameter in the event of a drive error. Simultaneously, bit Drive lock, error in class 1 diagnostics is set in the **drive status word.**

All bits in class 1 diagnostics, are cleared upon execution of the command **S-0-0099, C500 Reset class 1 diagnostic**.

(See section: "Clearing Errors")

The following bits are supported in status class 1.

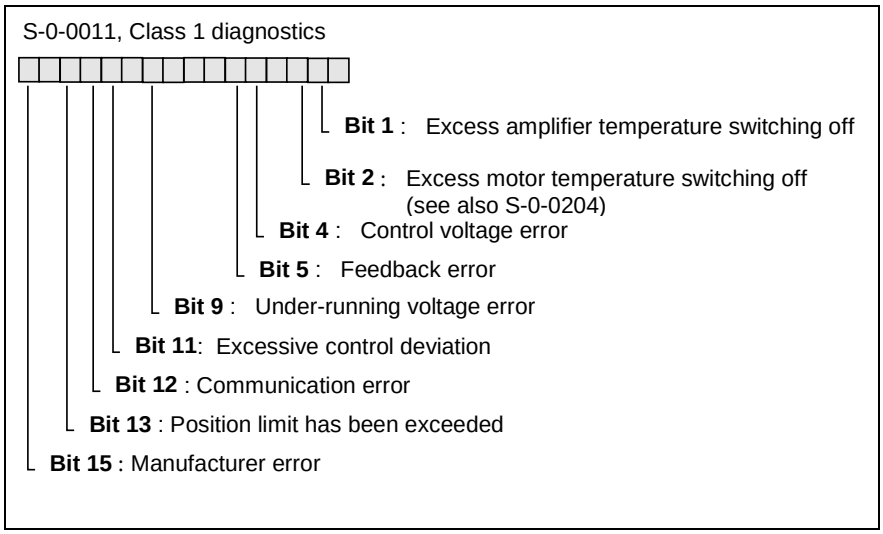
S-0-0011, Class 1 diagnostics
Bit 1 : Excess amplifier temperature switching off
Bit 2 : Excess motor temperature switching off
(see also S-0-0204)
Bit 4 : Control voltage error
Bit 5 : Feedback error
Bit 9 : Under-running voltage error
Bit 11: Excessive control deviation
Bit 12 : Communication error
Bit 13 : Position limit has been exceeded
Bit 15 : Manufacturer error

Fig. 4-13: S-0-0011, Class 1 diagnostics

## S-0-0012, Class 2 diagnostics

*Toggeling a bit is signalled with a change bit in the drive status word*

There are bits for various warnings in this parameter. In the event of a warning, a bit is set in this parameter. Simultaneously, bit Change bit class 2 diagnostics is set in the **drive status word.** This change bit is cleared by reading **S-0-0012, Class 2 diagnostics.** Via parameter **S-0-0097, Mask class 2 diagnostic** warnings can be masked in terms of their effect on the change bit.

The following bits are supported in class 2 diagnostics.

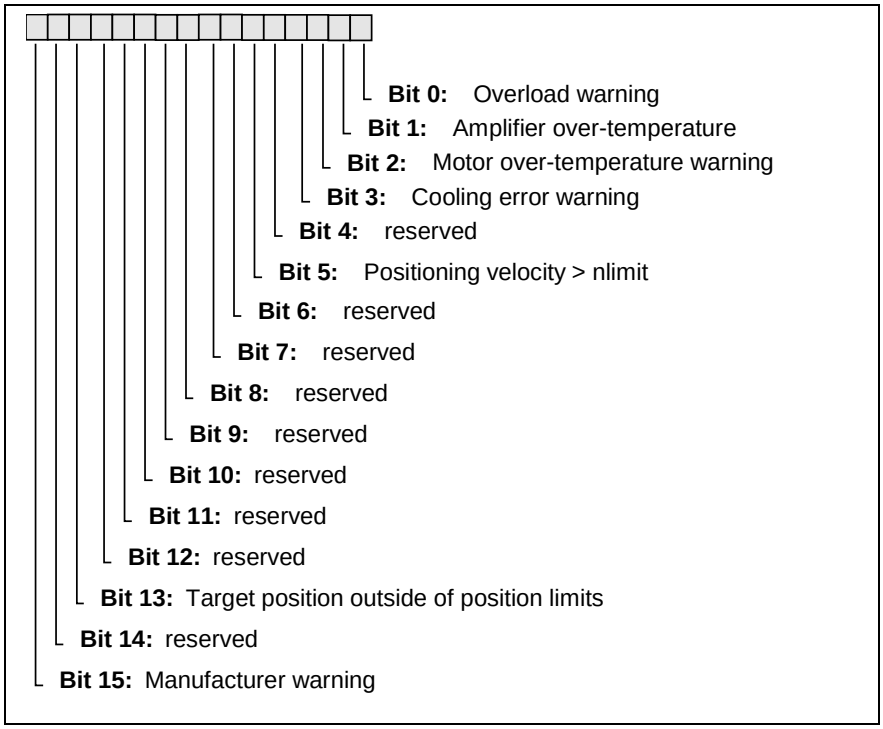


Fig. 4-14: S-0-0012, Class 2 diagnostics

Each of these messages is stored in turn in its own parameter (S-0-0310..S-0-0323).

## S-0-0013, Class 3 diagnostics

Various messages about operating states are stored here . If the state of a message changes, then a bit is set here as well in **drive status word** (**Change bit class 3 diagnostics**). This change bit is cleared again by reading **S-0-0013, Class 3 diagnostics.** Via parameter **S-0-0098, Mask class 3 diagnostic** warnings can be masked in terms of their effect on the change bit.

The following bits are supported in class 3 diagnostics.

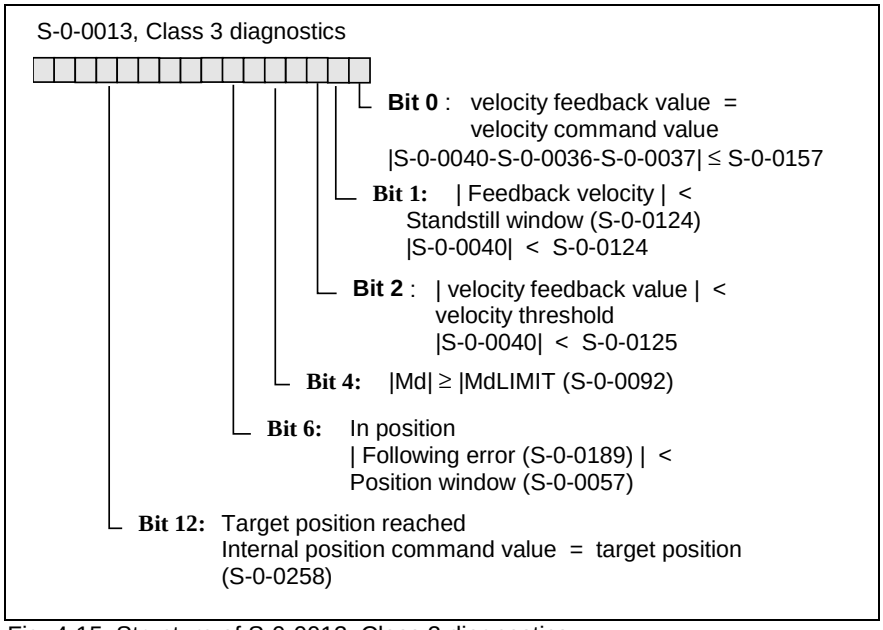
S-0-0013, Class 3 diagnostics
Bit 0 : velocity feedback value = velocity command value
|S-0-0040-S-0-0036-S-0-0037| ≤ S-0-0157
Bit 1: | Feedback velocity | < Standstill window (S-0-0124)
|S-0-0040| < S-0-0124
Bit 2 : | velocity feedback value | < velocity threshold
|S-0-0040| < S-0-0125
Bit 4: |Md| ≥ |MdLIMIT (S-0-0092)
Bit 6: In position
| Following error (S-0-0189) | < Position window (S-0-0057)
Bit 12: Target position reached
Internal position command value = target position (S-0-0258)

Fig. 4-15: Structure of S-0-0013, Class 3 diagnostics

Each of these messages is stored in turn in its own parameter (S-0-0330..S-0-0342).

## Change bit of class 2 and 3 diagnostics in the drive status word

If the state of a bit changes in **S-0-0012, Class 2 diagnostics** or **S-0-0013, Class 3 diagnostics** then the change bit status class 2 or 3 is set in the drive status word. A read access to both parameter clears this change bit. By setting the change bit as a result of a bit toggle in S-0-0012 or S-0-0013 it is possible to mask with the help of parameter **S-0-0097, Mask class 2 diagnostic** or **S-0-0098, Mask class 3 diagnostic**.

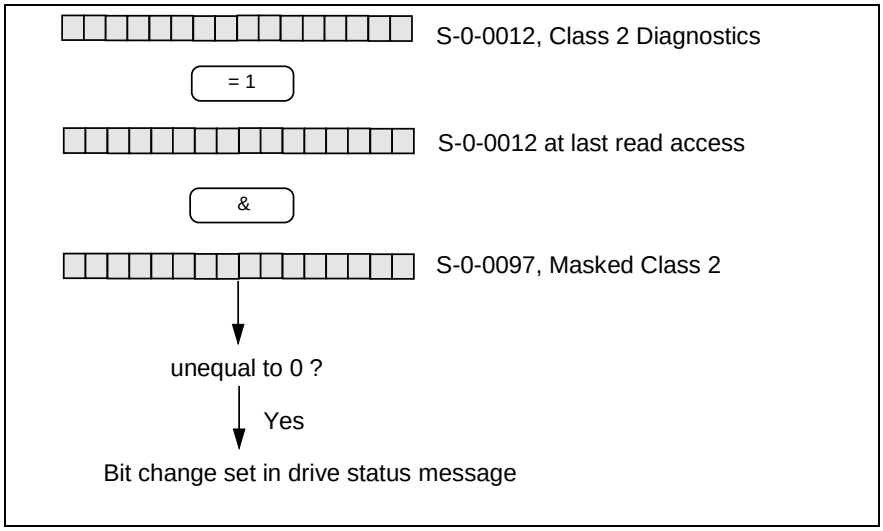


Fig. 4-16: Generating the change bit of class 2 diagnostics

## S-0-0182, Manufacturer class 3 diagnostics

In parameter **S-0-0182, Manufacturer class 3 diagnostics** various messages about the operating states are stored there as well. If the state of a message changes, then this is not signalled with a change bit.

The following bits are supported in manufacturer's class 3 diagnostics.

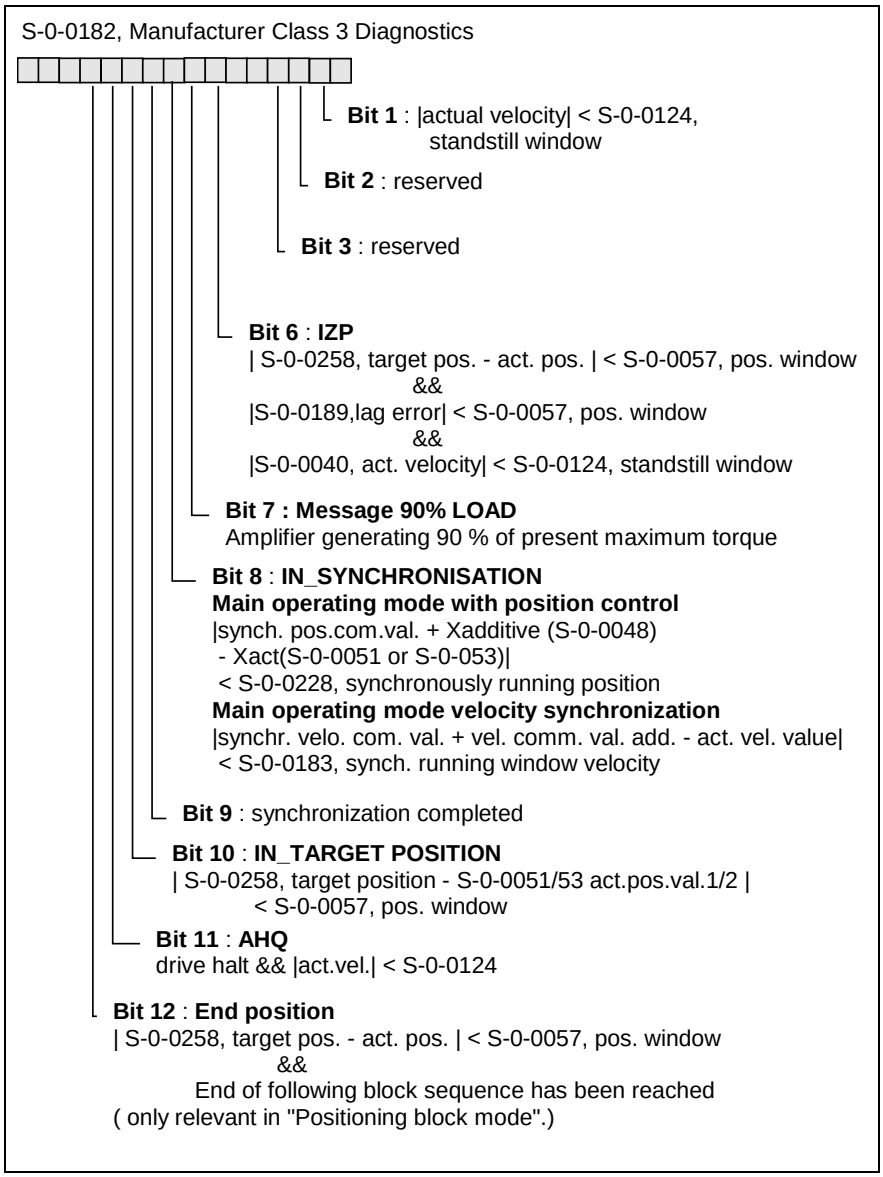
S-0-0182, Manufacturer Class 3 Diagnostics
Bit 1 : |actual velocity| < S-0-0124, standstill window
Bit 2 : reserved
Bit 3 : reserved
Bit 6 : IZP
| S-0-0258, target pos. - act. pos. | < S-0-0057, pos. window
&&
|S-0-0189,lag error| < S-0-0057, pos. window
&&
|S-0-0040, act. velocity| < S-0-0124, standstill window
Bit 7 : Message 90% LOAD
Amplifier generating 90 % of present maximum torque
Bit 8 : IN_SYNCHRONISATION
Main operating mode with position control
|synch. pos.com.val. + Xadditive (S-0-0048)
- Xact(S-0-0051 or S-0-053)|
< S-0-0228, synchronously running position
Main operating mode velocity synchronization
|synchr. velo. com. val. + vel. comm. val. add. - act. vel. value|
< S-0-0183, synch. running window velocity
Bit 9 : synchronization completed
Bit 10 : IN_TARGET POSITION
| S-0-0258, target position - S-0-0051/53 act.pos.val.1/2 |
< S-0-0057, pos. window
Bit 11 : AHQ
drive halt && |act.vel.| < S-0-0124
Bit 12 : End position
| S-0-0258, target pos. - act. pos. | < S-0-0057, pos. window
&&
End of following block sequence has been reached
( only relevant in "Positioning block mode".)

Fig. 4-17: Structure of S-0-0182, Manufacturer class 3 diagnostics

## 4.5 Language Selection

With the parameter **S-0-0265, Language Selection** you can switch between several languages for

- Parameter names and units
- Diagnostic texts

The following languages are implemented:

| Value of S-0-0265: | Language: |
|---|---|
| 0 | German |
| 1 | English |
| 2 | French |
| 3 | Spanish |
| 4 | Italian |

Fig. 4-18: Language Selection

## 4.6 Firmware Update with the Dolfi Program

With the help of the Dolfi program it has become possible to conduct firmware updates for a drive controler via the serial interface.

The program can be ordered from Indramat with item number:

-SWA-DOL*PC-INB-01VRS-MS-C1,44-COPY

or material number 279804.

This includes an extensive description of the program as well.

### Error Message in the Firmware Loader

If a firmware update is conducted with a serial interface (using the SIS protocol), then the drive can generate error messages.

Dolfi and the display on the drive read as follows:

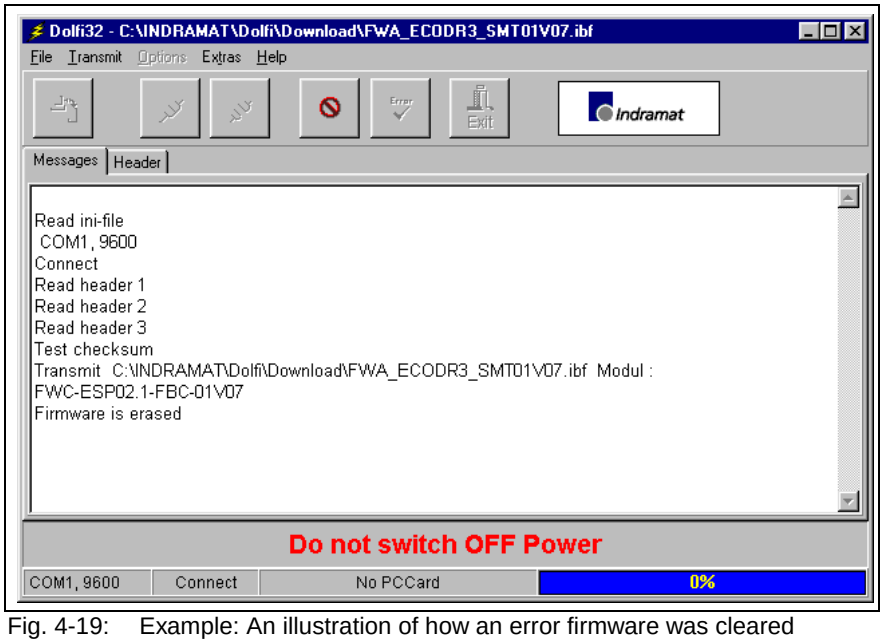


Fig. 4-19: Example: An illustration of how an error firmware was cleared

The table below lists the error messages:

| SIS error message | 7 segment display | Error message: |
|---|---|---|
| 0x9002 | dL / 00 | Firmware was cleared |
| 0x9003 | - | Loading into phase 3 not allowed |
| 0x9004 | - | Loading into phase 4 not allowed |
| 0x9102 | dL / 03 | Firmware was cleared |
| 0x9103 | - | Restart in phase 3 not allowed |
| 0x9104 | - | Restart in phase 4 not allowed |
| 0x9200 | dL / 06 | Read error |
| 0x9400 | dL / 07 | Timeout during reset |
| 0x9402 | dL / 0F | Address range not within flash storage |
| 0x940A | dL / 08 | Reset only in loader possible |
| 0x960A | - | Programming only possible in loader |
| 0x96E0 | dL / 0b | Error during flash verification |
| 0x96E1 | dL / 0C | Timeout when programming flash |
| 0x96FF | dL / 09 | Error when writing into RAM |
| 0x9701 | dL / 0d | Addition checksum faulty |
| 0x9702 | dL / 0E | CRC32 checksum faulty |

Fig. 4-20: SIS error of firmware loader

**Note:** While the firmware is being updated, the display of the drive reads "**dL**".

## 0x9002 (dL / 00) Firmware was cleared

**Description:** a) Programming the module FBC bootkernel or FIL firmware loader.

Firmware FIL is running, or the bootkernel must be replaced. To do so, the command "Drive firmware shutdown“ must be sent, i.e., the control must go from the FIL module to the FGP, SGP or SMT module. During the transition it is checked whether the checksum of the FGP, SGP or SMT is correct to ensure that the module was correctly programmed and can be called up. This checksum check went wrong.

b) Modules FGP, SGP or SMT must be programmed.

Firmware FGP, SGP or SMT must be replaced. To do so, the command "Shutdown, Loader“ must be sent. This means that the control must change from module FGP, SGP or SMT into module FIL: During the transition it is checked whether the addition checksum of the FIL module is correct or not to ensure that the module was correctly programmed and can be conducted. This checksum check went wrong.

**Clearing the errors:** On a)

Prior to programming the FIL it is necessary to program modules FGP, SGP or SMT.

On b)

Prior to programming FGP, SGP or SMT it is necessary to program FIL.

### 0x9003 Loading into phase 3 not allowed

**Description:** The drive is in phase 3. A change to the firmware loader is necessary because the firmware is to be replaced. This can only be done in phase 2.

**Clearing errors:** Switch the drive into phase 2.

### 0x9004 Loading into phase 4 not allowed

**Description:** The drive is in phase 4. A change to the firmware loader is necessary because the firmware is to be replaced. This can only be done in phase 2.

**Clearing errors:** Switch the drive into phase 2.

### 0x9102 (dL / 03) Firmware was cleared

**Description:** The drive firmware is to be restarted after the firmware was replaced. The programming of modules FGP, SGP or SMT was incomplete (addition checksum check went wrong).

**Clearing errors:** Modules FGP, SGP or SMT must be reprogrammed.

### 0x9103 Restart in phase 3 not allowed

**Description:** The drive is in phase 3 and the drive firmware must be restarted. This can only be done in phase 2.

**Clearing errors:** Switch the drive into phase 2.

### 0x9104 Restart in phase 4 not allowed

**Description:** The drive is in phase 4 and the drive firmware must be restarted. This can only be done in phase 2.

**Clearing errors:** Switch the drive into phase 2.

### 0x9200 (dL / 06) Read error

**Description:** A memory module is to be read. An error occurred while making the attempt.

**Clearing errors:** Check address range in the *.ibf file. If it is alright, i.e., a memory module is actually at that address, then the error can only be cleared by replacing the firmware module ESF02.1.

### 0x9400 (dL / 07) Timeout during reset

**Description:** An error occurred while trying to reset a flash.

**Clearing errors:** Repeat the reset command. If the error continues to appear, then it can only be cleared by replacing firmware module ESF02.1.

### 0x9402 (dL / 0F) Address range not in flash

**Description:** An address range not in the flash must be cleared.

**Clearing errors:** Correct address range in the SIS or check the range in the *.ibf file.

### 0x940A Reset only possible in loader

**Description:** Drive firmware is running and the flash is to be cleared.

**Clearing errors:** Change into firmware loader.

### 0x96E0 (dL / 0b) Error when verifying the flash

**Description:** An error occurred during the programming process. A memory cell in the flash could not be write accessed.

**Clearing errors:** The flash must be cleared prior to the programming command. If the error continues, then the firmware module ESF02.1 must be replaced.

### 0x96E1 (dL / 0C) Timeout when programming the flash

**Description:** An error occurred during programming. A memory cell in the flash could not be write accessed.

**Clearing errors:** Programming command repeated. If the error continues, then the firmware module ESF02.1 must be replaced.

### 0x96FF (dL / 09) Error when write accessing the RAM

**Description:** An error occurred during programming. A memory cell in the flash could not be write accessed.

**Clearing errors:** Check whether the target address is actually in the RAM. If the error continues, then the firmware module ESF02.1 must be replaced.

### 0x9701 (dL / 0d) Wrong checksum

**Description:** The programmed checksum is checked at the end of the updating of the firmware module. This check went wrong.

**Clearing errors:** Reprogram the module, check the checksum of the source file (*.ibf).

### 0x9702 (dL / 0e) CRC32 checksum faulty

**Description:** The programmed CRC32 checksum is checked at the end of the updating of the firmware module. This check went wrong.

**Clearing errors:** Reprogram the module, check the checksum of the source file (*.ibf).

## Additional Problems when Loading Firmware

### The programming of a module was terminated

Problems on the serial interface can lead to the termination of a transmission.

In the event that the loading procedure of the FBC module was terminated, then do not switch the unit off. This module is responsible for starting the firmware and therefore absolutely necessary.

A module that has not been completely programmed can simply be reprogrammed (open ibf file, press transmit button, in the "Send" window, select *Module single* and by *skipping,* find the right module. Now press the send button).

### After the unit is switched on, the display reads dL

The last programming procedure with Dolfi was not correctly completed.

To leave the firmware loader on one or all of the modules of an *.ibf file must be programmed with Dolfi. The drive firmware is started by pressing the separate button.

## Dolfi can be used to establish a connection

a) A baud rate other than Dolfi was set in parameter P-0-4021.

**P-0-4021, Baud Rate RS-232/485**:

| Baud rate [Baud] | Setting in parameter P-0-4021 |
|---|---|
| 9600 | 0 |
| 19200 | 1 |

It is advisable to set parameter P-0-4021 to 0 for "Connecting process“ (=9600 Baud). The baud rate for the download can be set to a different value in Dolfi.

If the programming of a module was terminated, e.g., due to interference at a serial interface, then the baud rate for the download is still set in a DKC. For Dolfi to be able to re-establish a connection, it is necessary to set the connect rate to the same value with which the most recent download occurred.

If the unit was switched back on and if the display reads dL, then a baud rate of 9,600 is always set.

b) The receiver and unit address is not identical with the address set at the controller via switches S2 and S3.

## Dolfi can not open the ibf file

Dolfi signals "Wrong ibf format“ when opening the ibf file.

The ibf file was generated with a different release and the ibf format has changed.

To open the file the correct Dolfi version must be used. This can be obtained from the manufacturer.

## Dolfi signals timeout

Timeout messages appear while the ibf files are being transmitted. Interference at the serial connections could be the problem or the deactivated COM interface FIFO.

This can be activated as follows:

**Windows 95:**

Start → Settings → System control → System → Unit manager → Connections (COM and LPT) → COM connections (COMx) → Connection settings → Expanded

→ Activate FIFO, Use standard setting

**Windows NT:**

Start → Settings → System control → Connections → COMx → Settings → Expanded

→ Activate FIFO

## Select the download baud rate

Depending on the length of serial interface cable there is a physical limit for the maximum baud rate at which serial communications runs without a fault.

The factory sets the maximum download baud rate at 19.2 kBd. The baud rate can be increased considerably in some applications which helps achieve a reduction in the time needed for a firmware update.

The following baud rates can be implemented at the specified cable lengths.

| Cable length / m | max. baud rate / kBd |
|---|---|
| 2 | 115.2 |
| 5 | 57.6 |
| 10 | 57.6 |
| 15 | 38.4 |

Fig. 4-21: Maximum baud rate as dependent on the cable length

# 5 Command Communication via Fieldbus

## 5.1 Bus-Independent Features

### Profile

For drive technology that uses a fieldbus system it was necessary to develop definitions for both process objects and status machines. Familiar are, for example, the DriveCom profile 22 of the INTERBUS Club, the ProfiDrive profile of the PROFIBUS User Organization and the Drive Profile DS402 for CANopen protocols. These profiles control only a small part of the necessary functions of a drive. The additional and especially valuable functions continue to remain manufacturer-specific.

Rexroth Indramat offers the user advanced drive functions with a simple-to-use interface. This is the case, for example, with the referencing and jogging functions in DriveCom which have been defined as an independent operating mode. These take the form (as defined in ProfiDrive as well) of a bit in the control word, thus offering the user a considerably more comfortable interface.

Long years of experience has lead to an optimized drive interface which is implemented so as to be fieldbus independent. The DriveCom and ProfiDrive functionalities, will, however, remain covered and only the position of the relevant bits in the control word and status word might change. Additionally, all the operating modes defined in the drive will be accessible via the fieldbus.

(see also chapter "Profile Types")

### Pertinent Parameters

The following parameters are relevant to external communications via a fieldbus:

- **P-0-4073, CANopen event mask**
- **P-0-4074, Fieldbus data format**
- **P-0-4075, Fieldbus watchdog time**
- **P-0-4076, Fieldbus container object**
- **P-0-4077, Fieldbus control word**
- **P-0-4078, Fieldbus status word**
- **P-0-4079, Fieldbus baudrate**
- **P-0-4080, Real-time input object structure**
- **P-0-4081, Real-time output object structure**
- **P-0-4082, Length of real-time data channel In**
- **P-0-4083, Length of parameter channel in DP**
- **P-0-4084, profile type**
- **P-0-4085, Fieldbus version**
- **P-0-4087, Length of real-time data channel Out**

The following parameters are relevant to the internal data exchange between drive and communications card:

- **S-0-0001, NC Cycle time (TNcyc)**
- **S-0-0002, SERCOS Cycle time (Tscyc)**
- **S-0-0007, Feedback acquisition starting time (T4)**
- **S-0-0008, Command valid time (T3)**

## Object mapping

Each drive parameter has an object number as specified in the following regulation. This makes it possible to best use the bus-specific communications (e.g., PCP, SDO,...). It is addressed via a direct computation of the SERCOS parameter number into an object number.

The allocation of an ID number to an index and sub-index (DKC03.3, DKC04.3, DKC05.3) or class, instance and attribute (DKC06.3) is unit dependent (see "

Command communications with DeviceNet").

The elements of the parameter can be addressed with the use of the sub-index or attribute:

| Sub-index/ attribute | Data type | Access | Description |
|---|---|---|---|
| 0 | UINT8 | R | Highest sub-index (CANopen only) |
| 1 | UINT16 | R/W | ID number |
| 2 | visible String | R | Name |
| 3 | UINT16 | R | Attribute |
| 4 | visible String | R | Unit |
| 5 | | R | Minimum input value |
| 6 | | R | Maximum input value |
| 7 | 2..32Byte | R/W | Operating data (as sub-index 10) |
| 8 | UINT16 | R | Maximum length of list (elements) |
| 9 | UINT16 | R/W | actual list length (elements) |
| 10 | 2..32Byte | R/W | operating data (as sub-index 7) |
| 11...137 | 2...32Byte | R | continuation of data with lists |

Fig. 5-1: Definition of sub-index / attributes

### Examples: reading a parameter

**Reading S-0-0057, Position window**

→**Index** = 0x2039, **Sub-index**=10 in PROFIBUS, INTERBUS and CANopen, (class = 101, instance = 57 attribute=10 in DeviceNet)

The response is 4 byte long as specified in the parameter description.

**Reading P-0-4006, Process block target position (list parameters !)**

a) →**Index** = 0x3FA6, **Sub-index**=9 in PROFIBUS, INTERBUS and CANopen, (class = 133, instance = 181 attribute=9 in DeviceNet)

The response is 2 bytes long and contains the actual length (number of elements) of the list.

b) →**Index** = 0x3FA6, **Sub-index**=10 in PROFIBUS, INTERBUS and CANopen, (class = 133, instance = 181 attribute=10 in DeviceNet)

The response is 4 byte long as specified in the parameter description, i.e., maximum 8 elements are transmitted per every four bytes.

### Examples: Writing a parameter

**Writing S-0-0057, Positioning window**

→**Index** = 0x2039, **Sub-index**=10 in PROFIBUS, INTERBUS and CANopen, (class = 101, instance = 57 attribute=10 in DeviceNet)

With a value of 4 bytes as per parameter description.

**Writing P-0-4006, Process block target position (list parameters !)**

a) →**Index** = 0x3FA6, **Sub-index** = 9 in PROFIBUS, INTERBUS and CANopen, (class = 133, instance = 181 attribute=10 in DeviceNet)

With a value of 2 bytes long which equals the actual length of the list (number of elements).

b) →**Index** = 0x3FA6, **Sub-index**=10 in PROFIBUS, INTERBUS and CANopen, (class = 133, instance = 181 attribute=10 in DeviceNet)

With the first two data bytes specifying a list offset (list element) and the following list elements of four bytes each as per parameter description.

**Note:** The number of valid user data within a telegram results automatically from the length specified in the PK control word. Up to 112 bytes can be transmitted within a telegram frame (distributed over several communication cycles).

## Setting the Slave Address

The address is set on the inserted firmware module.

**State at delivery:** **Default address: 99**

The address of ECODRIVE03 is set to 99 at delivery.

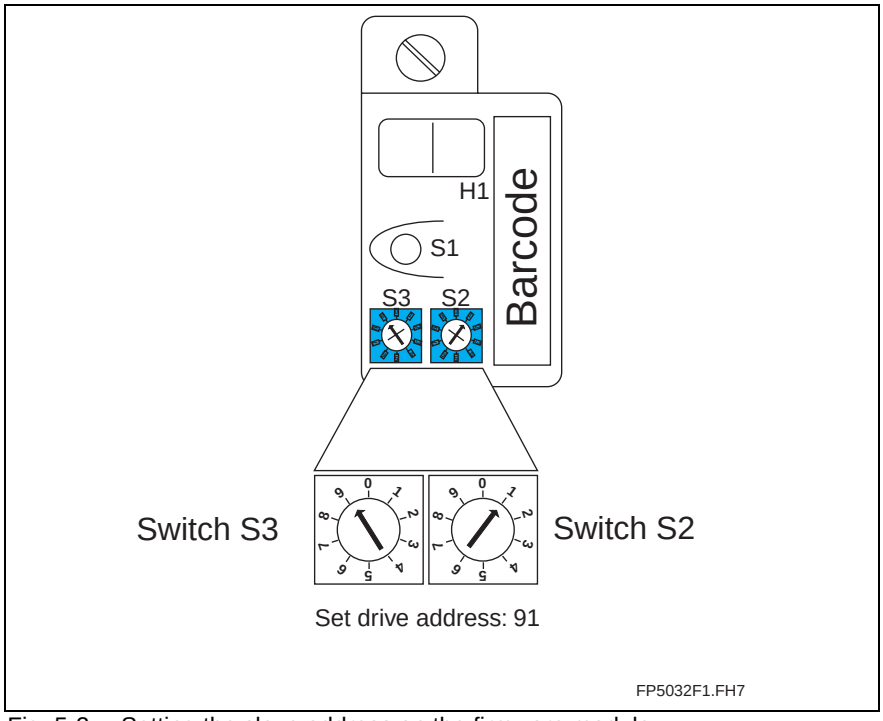


Fig. 5-2: Setting the slave address on the firmware module

**Programmable addresses**

The ECODRIVE03 controller supports slave addresses: 1...99 (decimal).

Depending from the field bus type, however, there are the following restrictions:

PROFIBUS-DP: **2 .. 99**

DeviceNet: **1 .. 64**

CANopen: **1 .. 99**

INTERBUS-S: INTERBUS addresses are automatically set by the master.

---

**Note:** The slave address 0 does not exist and may not be used in any applications.

---

**Slave address must be set before switching on!**

The ECODRIVE03 address is read while booting up the drive controller out of the parametrization mode into the operating mode and used to parametrize the fieldbus connection.

This means that a change in a slave address does not become effective until the drive controller has powered up.

# Drive Parametrization via Fieldbus

## Simple fieldbus overlapping parameter access with object assignment (e.g., index, sub-index)

A parametrization of the drive requires the transmission of numerous parameters and lists that are retained in accordance with the SERCOS specification.

Parametrization is possible via:

- a serial interface (e.g., DriveTop) or
- the relevant parameter channel of the fieldbus (e.g., PCP). All parameters of **Group 0** (S-0-xxxx, P-0-xxxx) can be R/W with object access.

Version FGP03VRS simplified parameter communication by introducing **fieldbus overlapping objects**.

---

**Note:** For detailed information see the relevant section.

---

## Backwards-compatible parameter accessing

For backwards compatibility to the present fieldbus versions (FGP01VRS and FGP02VRS) the data exchange objects and the option of parametrization as per SIS telegram definition remain available. This is why the structure and definition of an SIS telegram is briefly discussed below.

Four data exchange objects with varying lengths are made available. These are only accessible via the acyclical services "**Read**" and "**Write**" of the relevant fieldbus.

| | | | | |
|---|---|---|---|---|
| Object | 5E70 | 16 | bytes | R/W |
| Object | 5E71 | 32 | bytes | R/W |
| Object | 5E72 | 64 | bytes | R/W |
| Object | 5E73 | 128 | bytes | R/W |

**Rexroth Indramat SIS protocol**

Reading and writing a parameter complies with the rules set forth in the Rexroth Indramat SIS protocol.

**Reading a parameter**

A parameter of a drive cannot be directly read but rather a specific sequence must be maintained:

1. Read request of a SERCOS parameter in SIS format ->Write
2. Read out of requested parameter in SIS format ->Read or error message (reaction telegram).

**Writing a parameter**

Writing a parameter also requires a specific sequence:

1. Write request of a SERCOS parameter in SIS format->Write
2. Read out reaction telegram → read (confirm or error message).

---

**Note:** The complete coding rules for the SIS protocol are specified in Attachment A: "Serial Communication - SIS-protocol".

---

**Structure of an SIS command telegram**

Every SIS command telegram is made up of:

- 7 bytes telegram header + start symbol
- 5 bytes user data header
- n bytes user data

**Telegram header**

| Byte | Name | Definition |
|---|---|---|
| 1 | STZ | start symbol (0x02) |
| 2 | CS | checksum (not relevant with fieldbus!) |
| 3 | DatL | data length (incl. user data header) in bytes |
| 4 | DatlW | repeat DatL |
| 5 | Cntrl | control byte |
| 6 | Dienst | ECODRIVE services |
| 7 | AdrS | address of sender |
| 8 | AdrE | address of receiver |

Fig. 5-3: Telegram header of the command telegram

**User data header**

| Byte | Name | Definition |
|---|---|---|
| 9 | Ctrl - Byte | control byte in user data header |
| 10 | drive addr. | address ECODRIVE |
| 11 | ParaTyp | parameter type |
| 12 | ParaNumL | parameter number low byte |
| 13 | ParaNumH | parameter number high byte |

Fig. 5-4: User data header of the command telegram

**User data (max. 115 bytes)**

| Byte | Name | Definition |
|---|---|---|
| 14 | user data | user data, bytes (Intel format) |
| 15 | user data | user data, bytes (Intel format) |

Fig. 5-5: User data of the command telegram

---

**Note:** The number of user data is determined by the data exchange object used.

---

**Coding the control and parameter information**

Coding the parameter number and the parameter type.

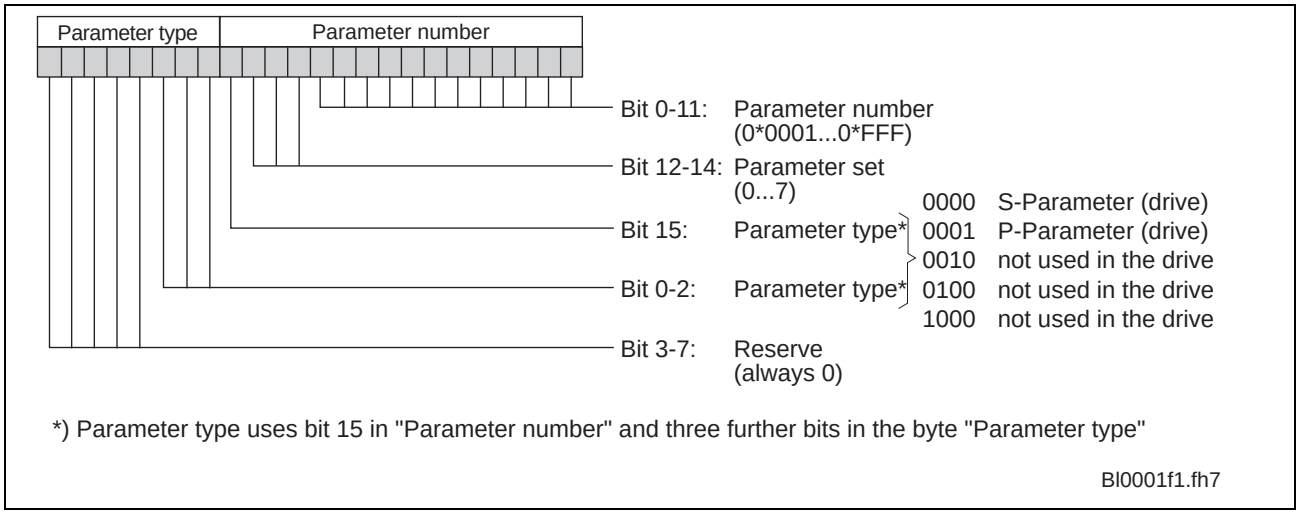
Parameter type
Parameter number
Bit 0-11: Parameter number (0*0001...0*FFF)
Bit 12-14: Parameter set (0...7)
Bit 15: Parameter type*
Bit 0-2: Parameter type*
0000 S-Parameter (drive)
0001 P-Parameter (drive)
0010 not used in the drive
0100 not used in the drive
1000 not used in the drive
Bit 3-7: Reserve (always 0)
*) Parameter type uses bit 15 in "Parameter number" and three further bits in the byte "Parameter type"
Bl0001f1.fh7

Fig. 5-6: Bytes 11-13 in the user data header

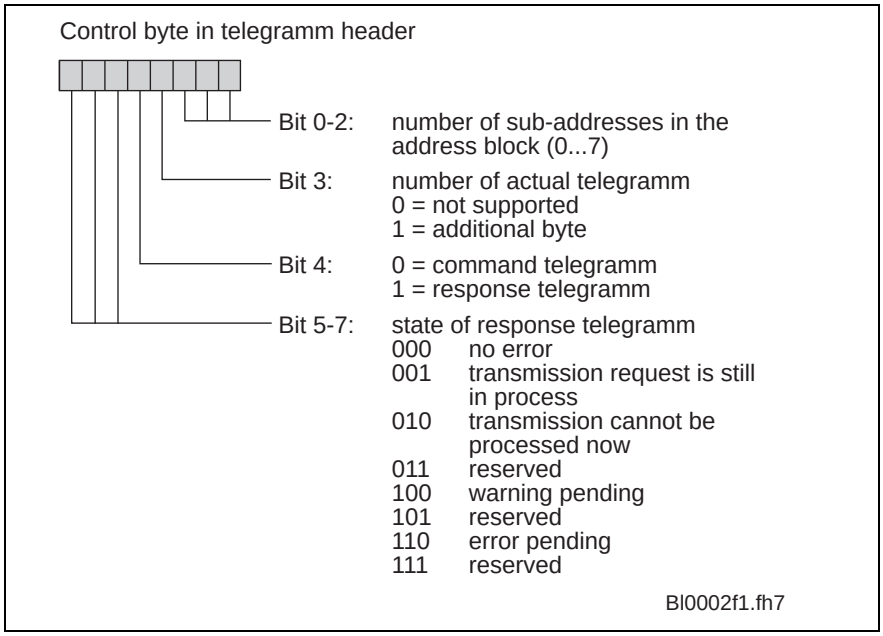
Control byte in telegramm header
Bit 0-2: number of sub-addresses in the address block (0...7)
Bit 3: number of actual telegramm
0 = not supported
1 = additional byte
Bit 4: 0 = command telegramm
1 = response telegramm
Bit 5-7: state of response telegramm
000 no error
001 transmission request is still in process
010 transmission cannot be processed now
011 reserved
100 warning pending
101 reserved
110 error pending
111 reserved
Bl0002f1.fh7

Fig. 5-7: Control byte (Byte 5) in the telegram header

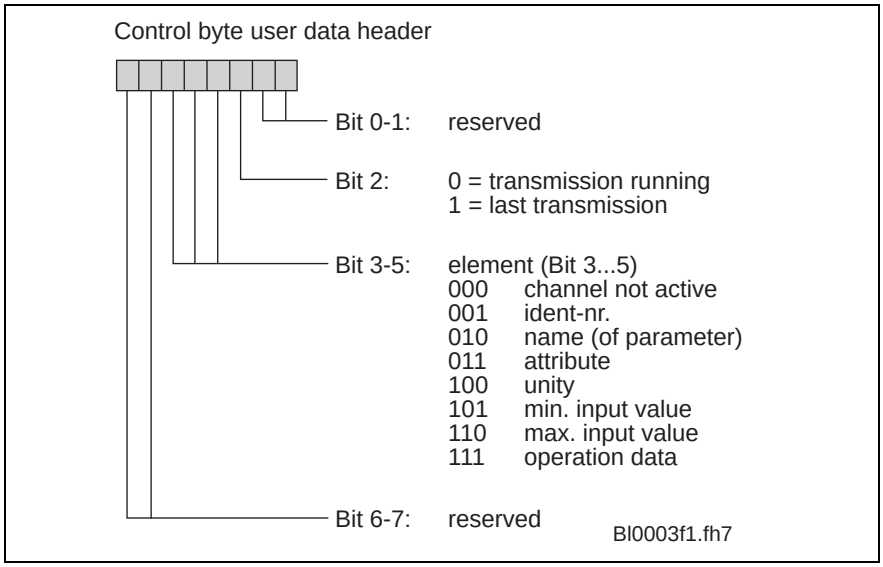


Fig. 5-8: Control byte (Byte9) in the user data header

**Structure of a status byte in a reaction telegram**

The status byte supplies the results of a transmission in the form of a code.

| Transmission status | Code numbers |
|---|---|
| transmission without error | 0x00 |
| protocol error | 0xF0... 0xFF |
| execution error | 0x01.... 0xEF |

Fig. 5-9: Transmission status in a reaction telegram

The following status information are presently in available:

| Protocol error | Code | Error description |
|---|---|---|
| Invalid service | 0xF0 | The requested service is not specified or is not supported by the participant addressed. |
| general protocol violation | 0xF1 | The command telegram cannot be evaluated (e.g., telegram length wrong). |

Fig. 5-10: Protocol error in the reaction telegram

| Execution error | Code | Error description |
|---|---|---|
| parameter processing error | 0x01 | An error occurred while R/W a parameter. |
| phase transition error | 0x02 | The specified target phase was not reached. |

Fig. 5-11: Execution error in the reaction telegram

**Structure of the SIS reaction telegram**

After sending a command telegram via a data exchange object, the drive makes a reaction telegram available. This telegram can be read with a read service via a data exchange object.

The SIS reaction telegram either contains data to be read or a diagnosis. To find out which, it is necessary to interpret the SIS telegram.

The structure of an SIS telegram is as follows:

**Telegram header**

| Byte | Name | Definition |
|---|---|---|
| 1 | STZ | start symbol (0x02) |
| 2 | CS | checksum (not relevant with fieldbus!) |
| 3 | DatL | data length (incl. user data header) in bytes |
| 4 | DatlW | repeat DatL |
| 5 | Cntrl | control byte |
| 6 | Service | ECODRIVE services |
| 7 | AdrS | address of sender |
| 8 | AdrE | address of receiver |

Fig. 5-12: Telegram header in the reaction telegram

**User data header**

| Byte | Name | Definition |
|---|---|---|
| 9 | Status | status byte in the user data header |
| 10 | Ctrl - Byte | control byte |
| 11 | AdrS | address of sender (unit address ECODRIVE) |

Fig. 5-13:User data header in the reaction telegram

**User data (max. 117 bytes)***

| Byte | Name | Definition |
|---|---|---|
| 14 | user data | user date, bytes (Intel format) |
| 15 | user data | user date, bytes (Intel format) |

Fig. 5-14: User data in the reaction telegram

**Using the data exchange object**

The choice of a suitable data exchange object is exclusively determined by the field length of the data that is to be transmitted.

The field length must span the entire SIS telegram!

The structure of this protocol permits data block splitting so that even lists with more than 117 bytes + header can be transmitted.

**Example : Reading a parameter**

## 1. Sending a read request

An SIS telegram is to be used to read the data of SERCOS parameter **P-0-4082, Length of real-time data channel In**.

**Telegram header**

| Byte | Name | Definition | Code |
|---|---|---|---|
| 1 | STZ | start symbol (0x02) | 02 |
| 2 | CS | checksum | xx |
| 3 | DatL | data length (incl. user data header) in bytes | 05 |
| 4 | DatlW | repeat DatL | 05 |
| 5 | Cntrl | control byte (command telegram) | 00 |
| 6 | Dienst | ECODRIVE services | 80 |
| 7 | AdrS | address of sender * | 00 |
| 8 | AdrE | address of receiver * | 05 |

Fig. 5-15: Telegram header in the command telegram (read P-0-4082)

*) sender address: here master address
receiver address: here slave address

**User data header**

| Byte | Name | Definition | Code |
|---|---|---|---|
| 9 | Ctrl - Byte | control byte in user data header | 3C** |
| 10 | drive addr. | address ECODRIVE | 05 |
| 11 | ParaTyp | parameter type | 00 |
| 12 | ParaNumL | parameter number low byte | F2* |
| 13 | ParaNumH | parameter number high byte | 8F* |

Fig. 5-16: User data header in the command telegram (read P-0-4082)

*) 0x8FF2 = Bit 15 = 1 -> parameter
FF2 = 4082 Dec. -> P-0-4082

**) operating data, final transmission

### 2. Reading a reaction telegram

By reading a reaction telegram via a data exchange object the data are transmitted in SIS format to the master.

**Telegram header**

| Byte | Name | Definition | Code |
|---|---|---|---|
| 1 | STZ | start symbol (0x02) | 02 |
| 2 | CS | checksum | xx |
| 3 | DatL | data length (incl. user data header) in bytes | 05 |
| 4 | DatlW | repeat DatL | 05 |
| 5 | Cntrl | control byte (reaction telegram) | 10 |
| 6 | Service | ECODRIVE services | 80 |
| 7 | AdrS | address of sender | 05 |
| 8 | AdrE | address of receiver | 00 |

Fig. 5-17: Telegram header in the reaction telegram (read P-0-4082)

**User data header**

| Byte | Name | Definition | Code |
|---|---|---|---|
| 9 | Status | status byte in the user data header | 00 |
| 10 | Ctrl bytes | control byte | 3C |
| 11 | AdrS | address of sender (unit address ECODRIVE) | 05 |

Fig. 5-18:User data header in the reaction telegram (read P-0-4082)

**User data**

| Byte | Name | Definition | Code |
|---|---|---|---|
| 14 | user data | low byte P-0-4032 | 0C |
| 15 | user data | high byte P-0-4082 | 0D |

Fig. 5-19:User data in the reaction telegram (read P-0-4082)

**Note:** The actual results, i.e., the contents of the parameter P-0-4082, are in bytes 14+15.

# 5.2 Command Communications with PROFIBUS-DP

## General Information

The drive controller ECODRIVE 03 has a PROFIBUS command communications module which supports the PROFIBUS-DP protocol.

It is possible with this module to transmit real time data via the process data channel. A master that only supports PROFIBUS-DP suffices.

**Optional parameter channel**

The drive can be parametrized via the optional parameter channel in the cyclical channel.

**Note:** To help simplify the introduction into fieldbus communications, Rexroth Indramat make function modules available for the S7. The principles used there are easily applicable to other fieldbus masters as well.

## Function Overview

The PROFIBUS command communications module has the following features:

- The command module supports interfaces in accordance with EN50170, vol. 2. Line types A and B as per EN50170, vol. 2, are also supported.
- All data rates as per EN50170, vol. 2, up to 12 Mbps if only PROFIBUS DP is used.
- Configurable process data channel up to 18 bytes in both data directions, additionally optional up to 14 bytes for the parameter channel.
- Backwards compatible to PROFIBUS functions of the DKC3.1.
- Process data channel monitored (watchdog function).
- LEDs on the front panel of the command communications module for easy diagnoses of bus functions and important communications relationships between drive and fieldbus.
- Upload/download function for all drive parameters including lists. Direct or via 4 arrays of 16 to 128 bytes data length with parameter channel are possible (Rexroth Indramat SIS protocol).
- Support of Set-param service by PROFIBUS-DP for easy start ups.

## PROFIBUS Interface

- To ensure EN standards for EMC safety, the PROFIBUS interface is completely galvanically decoupled.
- As per EN50170, vol. 2, the module has a 9-pin D-subminiature plug-in connector for coupling a PROFIBUS.
- To switch through BUS signals to the other bus participants, Rexroth Indramat plug-in connector INS 0450 is available.

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**Note:** The BUS coupling as spur is directly in the plug-in connector INS 0450. Given transmission rates of >500kbit this particular plug-in connector must be used. No further spurs or additional plug-in connectors are allowed.

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- To maintain the BUS functions it is necessary that the unit into which the connector with bus connection is inserted, is always in operation.

## Setting a Slave Address and Transmission Rates

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**Note:** Slave addresses 0 and 1 are reserved and may only be used for slave applications.

The transmission rate is set in the master and automatically recognized in the slave.

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# Parameter Channel in the DP

As it must be possible to parametrize the drive via the fieldbus, a configurable parameter channel has been implemented in the cyclical data of the ECODRIVE03. Its size has been set to max. 14 byte.

## Definition of Terms

**Cyclical data channel**

The fieldbus makes data containers available in which cyclical user data is transported. This is defined as the cyclical data channel.

This cyclical data channel is broken down into

- a process data channel (real time channel) and
- an (optional) parameter channel.

**Process data channel**

The real time channel (Process data channel) contains permanently programmed information. Thus the receiver can directly interpret this information.

**Parameter channel**

Parameters in general can be transported in the parameter channel. To read parameters, however, the PLC must first receive a read request in writing. This is why the parameter channel has no "Real time features".

The cyclical data channel can be configured via the following parameters:

| Parameter | Definition | I/O mode | Interpolation |
|---|---|---|---|
| P-0-4082 | Length of real-time data channel In (Slave→Master) in bytes | 2 | 24 |
| P-0-4087 | Length of real-time data channel Out (Slave→Master) in bytes | 2 | 24 |
| P-0-4083 | Length of parameter channel in DP | 0 | 12 |

Fig. 5-20: Parameters to configure the cyclical data channel

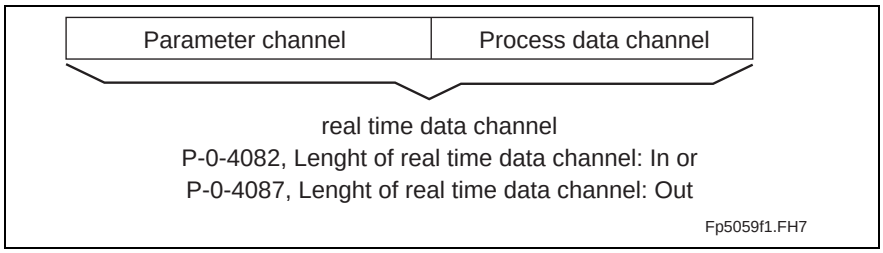
Parameter channel
Process data channel
real time data channel
P-0-4082, Lenght of real time data channel: In or
P-0-4087, Lenght of real time data channel: Out
Fp5059f1.FH7

Fig. 5-21: Structure of the cyclical channel

**Note:** The parameter channel is always at the start of the cyclical data channel. The length of the parameter channel and the length of the process data channel used to exchange real time data represent the entire length of the cyclical data channel.

## Handling of the "new" parameter channel

In firmware version FGP03VRS the parameter channel has been expanded and its use simplified. This chapter describes its structure and functionalities.

**Arrangements of the bits in the control and status word**

The control word is send in direction from the master to the slave. It is 16 bit wide and the single bits have the following meaning:

**control word**

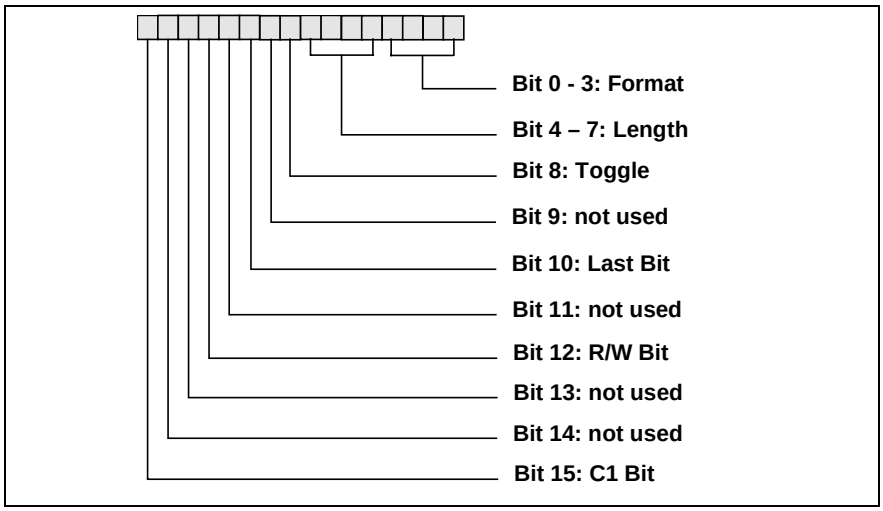
Bit 0 - 3: Format
Bit 4 – 7: Length
Bit 8: Toggle
Bit 9: not used
Bit 10: Last Bit
Bit 11: not used
Bit 12: R/W Bit
Bit 13: not used
Bit 14: not used
Bit 15: C1 Bit

Fig. 5-22: Arrangement of bits in the control word

The single bits have the following meaning:

Format: These bits describe the usage and meaning of the data in the parameter channel. At the moment, only one format is defined.

Length: These four bits specify the length of the valid data without the control word in the parameter channel. The data in the rest of the parameter channel is undefined.

Toggle: This bit toggles with every new sent data. It is used for a handshake between master and slave. The master is only allowed to send this bit, when the toggle bit in the status word has the same level as the toggle bit he sent in the control word.

L: Last bit. This bit is set when the last fragment of a data block is sent. This tells the slave that the transmitted data segment is complete.

R/W: Read/Write; Read = 1, indicates that the master wants to read data.

C1: This bit is used to distinguish between the "old" and "new" handling of the parameter channel. For the "new" handling, it must be fixed to 1.

**Note:** Not used bits must be set to 0.

**Status word**

The status word is in direction from the slave to the master. It is 16 bit wide and the single bits have the following meaning:

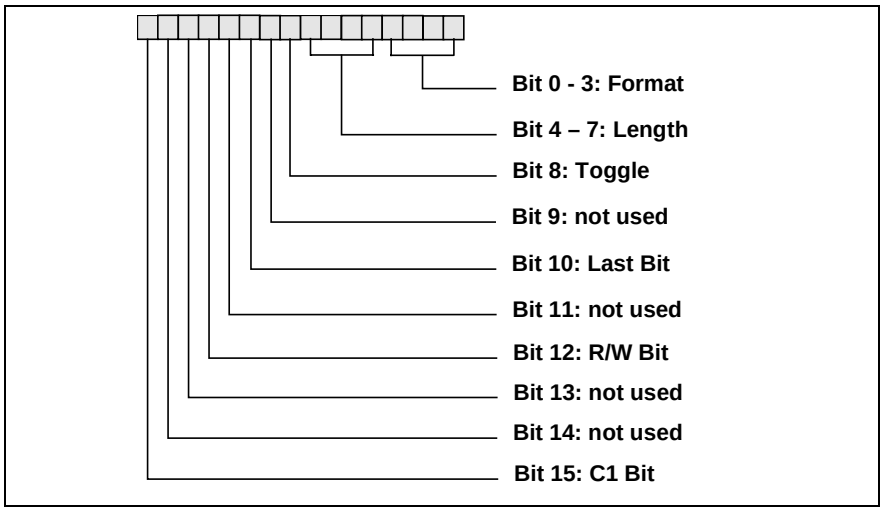
Bit 0 - 3: Format
Bit 4 – 7: Length
Bit 8: Toggle
Bit 9: not used
Bit 10: Last Bit
Bit 11: not used
Bit 12: R/W Bit
Bit 13: not used
Bit 14: not used
Bit 15: C1 Bit

Fig. 5-23: Arrangement of bits in the status word

The single bits have the following meaning:

Format: These bits describe the usage and meaning of the following data in the parameter channel. At the moment, only one format is defined.

Length: These four bits specify the length of the valid data without the status word in bytes. The data in the rest of the parameter channel is undefined.

Toggle: This bit toggles with every new sent data. It is used for a handshake between master and slave. The slave recognises new data, when the toggle bit he receives (control word) is different from the toggle bit in the status word.

L: Last bit. This bit is set when the last fragment of a data block is sent.

R/W: Read/Write; Read = 1, indicates that the master wants to read data.

Error bit: This bit indicates an error that occurred within the slave. The reason for the error is coded in the following data.

C1: This bit is used to distinguish between the "old" and "new" handling of the parameter channel. For the "new" handling, it must be fixed to 1

**Note:** Not used bits must be set to 0.

**Communication between master and slave**

A general way to describe the different communication relationships can be seen in the following graphics, here the two used services of the parameter channel

- Read Request
- Write Request

are shown from the master side.

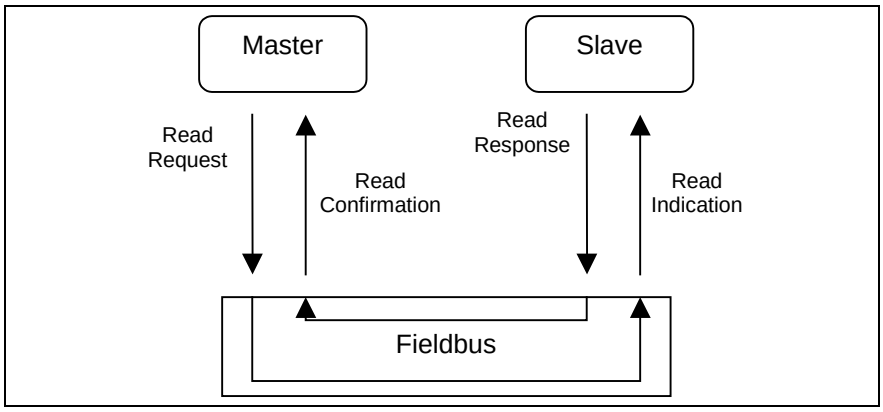


Fig. 5-24: Master wants to read data

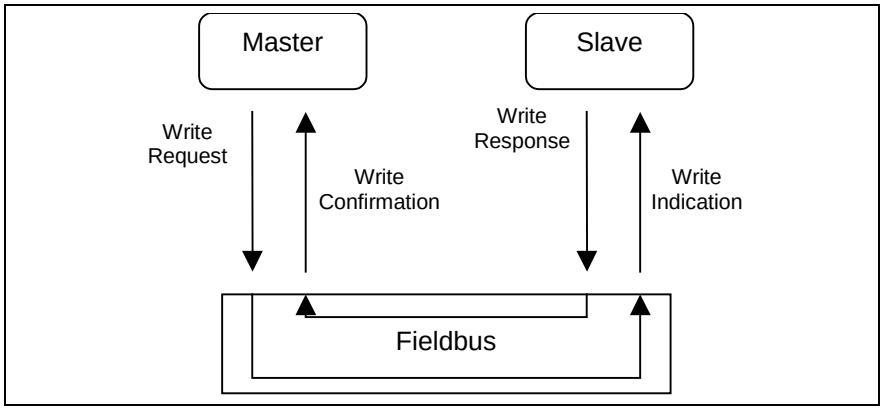


Fig. 5-25: Master wants to write data

Hereby, the request and the indication as well as the response and the confirmation contain the same data, the difference is just the point of view. (master or slave)

The first word is the control word, if a service request is sent from the master to slave. If a service request is sent from slave to master the first word is called status word. These words control the handshake for parameter channel (PK).

When the transmitted data is longer than the length of the PK, the data have to be fragmented. The necessary information for the fragmentation is hereby also contained in the control/status word. The general usage of the PROFIBUS DP channel can be seen in the following picture (Length of PK: 3 words, length of process data channel: 3 words). The complete length of the transferred data can be up to 128 bytes. It depends on the used format, if further limitations exist.

<table>
<tr><td></td><td>Word 63 of PK</td><td>Word 64 of PK</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td></td><td>...</td><td>...</td></tr>
<tr><td></td><td>Word 3 of PK</td><td>Word 4 of PK</td></tr>
<tr><td>Status / Control word</td><td>Word 1 of PK</td><td>Word 2 of PK</td><td>Word 1 of process data</td><td>Word 2 of process data</td><td>Word 3 of process data</td></tr>
<tr><td colspan="3">Parameter channel PK</td><td colspan="3">process data channel</td></tr>
<tr><td colspan="6">Cyclic channel</td></tr>
</table>

Fig. 5-26: Contents of the PROFIBUS DP channel

The transmitted data is highly dependant on the used format. At the moment, only one format is defined for the "new" parameter channel. It is called "Format 3" and has the format code 1100b in the format nibble of the control / status word.

For a further explanation of the communication using the PK, an example will be used with the following assumptions:

- Format is format 3: 1100b
- PK is in total 4 words long
- Reading or writing will be done to index 0x2001, sub-index 0x02

In the following example, we are less interested in the user data, but more in the handling of the control and status word. The control / status word will be displayed in its single bits, while the rest of the PK is displayed in the single bytes. In this documentation the capital letter "X" had been used to display undefined data, while "d" had been used to display a certain value that is not known. The first example is to read a parameter value.

**Reading a value**

The master indicates reading by setting the R bit. In this example a parameter is addressed by its index and sub-index, hence, no further data is needed. The length is set to four, giving the valid length in the following user data in bytes. The toggle bit is set to 1, assuming that it had the value 0 before. The L bit is set because all the necessary information had been sent within one block of data.

| | Control word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | | R | | L | | T | Length | | | | Format | | | | Index (HB) | Index (LB) | | Subindex | Data | Data |
| **M** | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0x20 | 0x01 | 0x00 | 0x02 | X | X |

Fig. 5-27: Read request by the master

The slave will return a read response that contains the necessary data (here 10 bytes). The length had been set to 6 and the toggle bit has the same level as from the master defined. Also the last bit had not been set, because only the first 6 byte of data could be sent in this fragment. Another fragment will be necessary to send the remaining data.

| | Status word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | E | R | | L | | T | Length | | | | Format | | | | Data | Data | Data | Data | Data | Data |
| **S** | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | d | d | d | d | d | d |

Fig. 5-28: Read response by the slave (first fragment)

Now the master has to toggle the toggle bit again to get the next fragment. The R/W- and L-bit, as well as the length and the user data are of no interest and will not be checked by the slave. However, the master should set these bits as shown in the graphic below.

| | Control word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | | R | | L | | T | Length | | | | Format | | | | Index (HB) | Index (LB) | | Subindex | Data | Data |
| **M** | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | X | X | X | X | X | X |

Fig. 5-29: Read request for the next fragment by the master

The slave will return the next fragment, containing the remaining 4 bytes of data. The L-bit is set, because it is the last fragment, the length had been set accordingly.

| | Staus word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | E | R | | L | | T | Length | | | | Format | | | | Data | Data | Data | Data | Data | Data |
| **S** | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | d | d | d | d | X | X |

Fig. 5-30: Read response by the slave (last fragment)

The timing for the complete reading of a parameter can be seen in the following graphic:

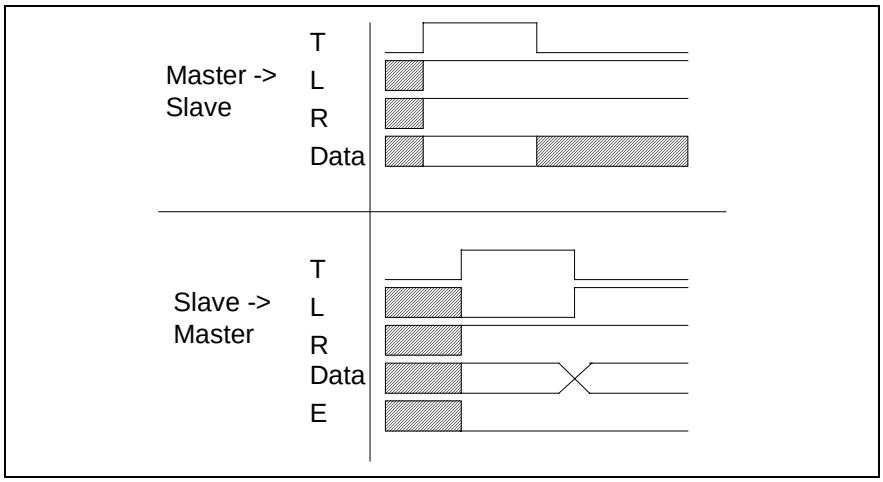


Fig. 5-31: Timing for reading

In case that an error will occur during the reading of the parameter, the error timing diagram will look like this:

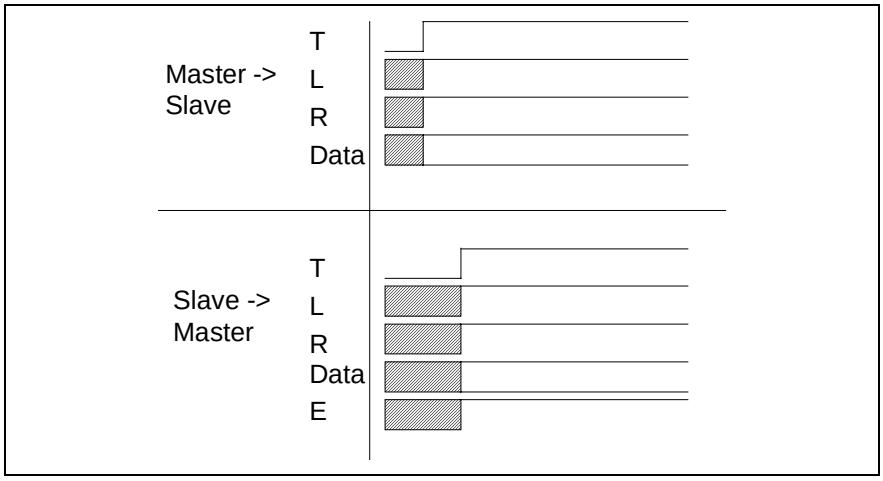


Fig. 5-32: Timing for an occurred error during reading

**Writing a value**

For writing a value an example will be used with the following assumptions:

- Format is format 3: 1100b
- PK is in total 4 words long
- Reading and writing will be done to index 0x3FBE (P-0-4030, Jog velocity), sub-index 0x07

The master indicates writing with the R bit set to zero. Index and sub-index must be provided as well as the data which should be written. In this example we assume that the data are 4 bytes long. The PK is too short for all the data, hence the L bit is not set, more data will follow. The toggle bits had been set to another level from the previous state.

| | Control word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | | R | | L | | T | Length | | | | Format | | | | Index (HB) | Index (LB) | | Subindex | Data | Data |
| **M** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0x3F | 0xBE | 0x00 | 0x07 | d | d |

Fig. 5-33: Write request by the master (fragment 1)

The slave will return a read response that contains no user data. This response just indicates the master, that the previous sent message had been recognised and new data can be sent. The status word is just a copy of the control word, just the length and the L-bit will be updated. However, the master should not check the L-, R- and the length.

| | Status word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | E | R | | L | | T | Length | | | | Format | | | | Data | Data | Data | Data | Data | Data |
| **S** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | X | X | X | X | X | X |

Fig. 5-34: Write response by the slave

Now the master has to sent the rest of the data in the next write request. Again, the toggle bit must be toggled, the length is updated and the L bit must be set, because this is the last fragment.

| | Control word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | | R | | L | | T | Length | | | | Format | | | | Data | Data | Data | Data | Data | Data |
| **M** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | d | d | X | X | X | X |

Fig. 5-35: Write request by the master (fragment 2)

The slave has now received all information and can process the master's request. As an acknowledge to the master, write response will be sent back to the master. It contains only the status word.

| | Status word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | E | R | | L | | T | Length | | | | Format | | | | Data | Data | Data | Data | Data | Data |
| **S** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | X | X | X | X | X | X |

Fig. 5-36: Write response by the slave

The timing for the complete writing of a parameter can be seen in the following graphic:

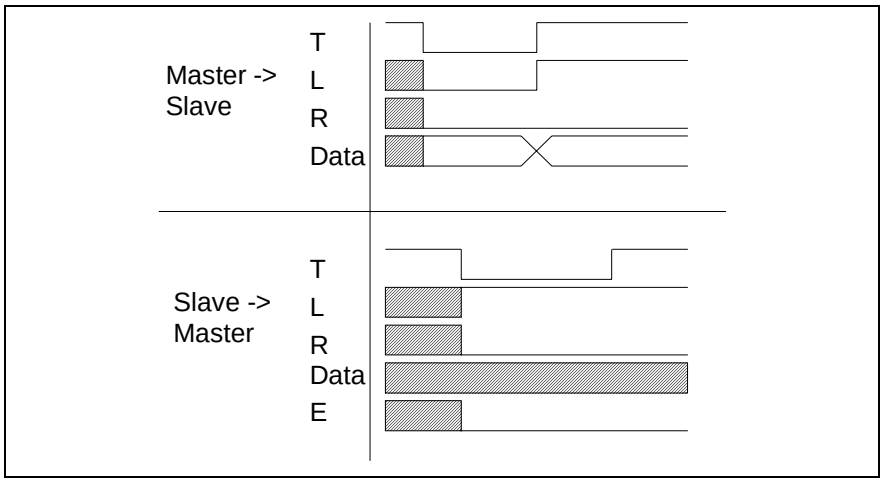


Fig. 5-37: Timing for writing

In case that an error will occur during the writing of the parameter, the error timing diagram will look like this:

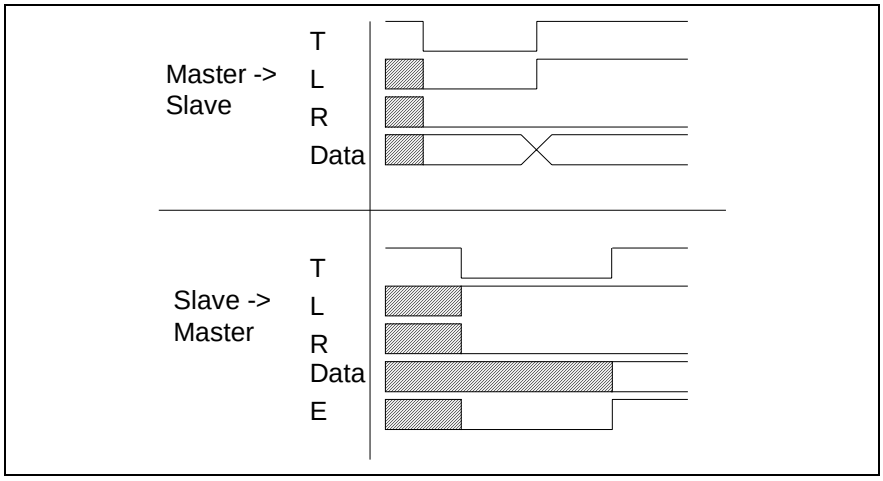


Fig. 5-38: Timing for an occurred error during writing

**Error messages**

In case that the slave has detected an error, it will generate an error message. It contains the error code as a 16 bit value. From the error code, the user can examine the cause of the error. The error message has the following arrangement for format 3:

| | Status word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | E | R | | L | | T | Length | | | | Format | | | | Error | code | Data | Data | Data | Data |
| **S** | 1 | 0 | 1 | d | 0 | 1 | 0 | d | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | d | d | X | X | X | X |

Fig. 5-39: Error response message of slave

The error bit is set and the R and T bit will have the same value as the master's sent bits. The error code is either a SIS error or an internal error code. The definition and explanation of the internal error codes are listed below. SIS errors are explained in a different chapter.

| Error code | Description |
|---|---|
| 0x0085 | The sum of all fragments that had been collected is too long |
| 0x0088 | Error occurred during communication between drive and fieldbus card |
| 0x008A | Given index does not exist |
| 0x008B | Format is not known |
| 0x008C | The valid length in the control word is longer than the PK |
| 0x008D | Communication is not possible, PK is too short (<= 2 byte) |
| 0x0090 | While collecting several fragments, the format has changed. |
| 0x0095 | When reading an index, data are sent in addition to index and sub-index. |
| 0x0096 | The internal SIS communication returned an error. |
| 0x009A | This function is not implemented |
| 0x009B | The PK is already in use by the "old" PK |
| 0x009C | Given sub-index does not exist |
| 0x009D | Sub-index is write protected. |
| 0x00F0 | Timeout during communication between drive and fieldbus card |

Fig. 5-40: Error codes

## Cancelling data transfer

**Cancelling data transfer**

In some cases it might be useful to be able to cancel an existing data transfer (in example: reading list elements and in between the master wants to stop the slave to send data). Indicating to the slave that it should stop all actions and wait for a new read or write command is done by setting the format bit to 0xF and the length, L- and R-bit to zero. The slave will change its internal state to expect a new command. The R-, L-bit and the length will not be checked, but should be set by the master in the shown way.

| | Control word | | | | | | | | | | | | | | | | User data | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C1 | | | R | | L | | T | Length | | | | Format | | | | Data | Data | Data | Data | Data | Data |
| **M** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | d | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | X | X | X | X | X | X |

Fig. 5-41: Cancelling transmission within fragmentation

## Data handling using format 3

The previous chapter described the usage of the parameter channel itself. In the chapters: "Object Directory PROFIBUS Specific" and "
Object mapping", the handling of the data within the data unit of the PK is described.

# Object Directory PROFIBUS Specific

There is no object directory defined in the PROFIBUS-DP. The acyclic accessing of drive parameters is only possible via the parameter channel.

To make acyclic parameter accessing as simple as possible (without SIS telegram), an introduction to and assignment of objects (index and sub-index) to drive parameters was conducted.

**Object definition**

The data of an object is accessed as follows:

- Index
- Sub-index

**Generating laws for the object index:**

- $\text{Index} = 0x2000 + \text{IDN}(S-0-XXXX)$ **S parameters**
- $\text{Index} = 0x3000 + \text{IDN}(P-0-XXXX)$ **P parameters**

**Generating laws for the object sub-index:**

(Also see "Bus-Independent Features")

**Example 1**: accessing data of S-0-0051

$\text{Index} = 0x2000 + \text{IDN}(S-0-0051) = 0x2000 + 51 = 0x2033$

Sub-index = 7 (or 10), as accessing of data is wanted

**Example 2**: accessing of data of P-0-0051

$\text{Index} = 0x3000 + \text{IDN}(P-0-0051) = 0x3000 + 51 = 0x3033$

Sub-index = 7 (or 10), as data accessing if wanted

# Unit master file for DKC03.3

Every **PROFIBUS-DP unit** must have a master file **(*.GSD**) in which the data is stored that is needed to operate the unit on the BUS. This file is needed for each subscriber at the time when the Bus master is configured.

**Unit master file for ECODRIVE03**

The unit master file for the ECODRIVE03 is an ASCII-file named ECO3100D.GSx, whereby "x" defines the language version (d = language independent, g = German)

The master file also contains the

ID number 100D hex

assigned by the PNO and needed for an ECODRIVE03.

**Note:** The GSD file is stored at installation of DriveTop in directory "Indramat\ Device Data Sheets".

# Configuration of the PROFIBUS-DP Slave

## Configuration of the process data channel

For the user, the PROFIBUS command communications module represents an intelligent PROFIBUS module which can be configured according to the process requirements.

The process data are configured independently of the fieldbus type.

The setting in **P-0-4084, Profile type** basically pre-determines the process data channel (real-time channel) setting.

**Note:** The configuration of profile types P-0-4084 = 0xFFFE (free configurable) or 0xFF82 (free expandable) is left to the user.

See also chapter: "Profile types"

Parametrization via the fieldbus is possible and the drive parameters can be write accessed via the parameter channel.

This configuration option, however, requires that the master implement the parameter channel. For S7 there are available PLC modules that make conversion a lot simpler.

**Note:** It applies to both the process input data and output data that changes in word length must always lead to modifications in the data stored in the master that were intended for the slave. This is why length changes in the DP channel do not become effective until the drive has been switched on again or with phase switching from parametrization into operating modes.

**P-0-4080, Real-time input object structure**

The structure and thus the number of words and their assignment with objects (indices) for the process input data are illustrated in this parameter.

The master can use this configuration to inform itself about the situation of the individual real time data on the bus.

**P-0-4081, Real-time output object structure**

The structure of the process output (master → slave) data is stored in this parameter. Thus it is possible via this parameter channel to read the current structure and thus the assignment at the BUS.

**Note:** Up to 18 words in both data directions can be configured at the BUS. Note here, that **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word** are always configured first.

**Data direction**

- **Data direction input**

The data direction input is the data transmission direction from slave to master.

- **Data direction output**

This data direction specifies data transmission from master to slave.

## Length of the process data channel PD in ECODRIVE 03

The parameter channel (optional) and the process data channel in which the real time data of the drive controller are transmitted, are allocated within the cyclical channel.

The PROFIBUS slave circuit permits a flexible configuration of the process data channel.

The length of the process data channel depends on the profile type which has been set. User-specific expansions of the process data channel can mean that individual drive controllers will have varying process data channel lengths, depending on the data direction.

**Note:** The available profile types are described in the chapter "Profile Types".

The data types of the process data channel can only be words or double words, not bytes. Length is specified in bytes for the sake of compatibility to other bus systems.

**Length of the PD channel**

The length of the process data channels can range between 1 to 9 words or 2 to 18 bytes in either direction.

### Setting the length of the PD channel in ECODRIVE 03

The length of the PD channel is specified in the contents of the configuration lists in P-0-4080 or P-0-4081 and can be read in parameters

- **P-0-4082, Length of real-time data channel In** (Slave → Master)
- **P-0-4087, Length of real-time data channel Out** (Master → Slave)

The setting becomes effective when the controller runs-up into operating mode. This is why it must be pre programmed.

**Note:** Note that a change in the length of the process data channel also needs a change in the master configuration. The set length of the data channel must agree with the length in the master.

## Configuration via SET_PRM Service of PROFIBUS-DP

When setting up a 'series produced' machine, for example, it makes sense to parametrize the drive from the fieldbus master. The master can, via service SET_PRM, basically parametrize the slave so that data length on the bus and in the operating mode of the drive are fixed. The user data of the SET_PRM service are generally set menu-driven via the configuration tool of the DP master with the help of the GSD file. These data (User_Prm_data) are documented below:

| **P-0-4083 Length PC** | | **P-0-4084 Profile type** | | **Number of elements of configuration list n in bytes** | | **P-0-4081, Real-time output object structure** | | | | | **P-0-4080, Real-time input object structure** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HB | LB | HB | LB | P-0-4081 | P-0-4080 | HB1 | LB1 | HB2 | LB2 | ... | HBn | LBn | HBn+1 | LBn+1 | ... |
| Word 1 | | Word 2 | | Word 3 | | Word 4 | | Word 5 | | ... | Word n | | Word n+1 | | ... |

Fig. 5-42: Assignment in User_Prm_data

## Diagnostic LEDs for PROFIBUS

There are four LEDs on the front of the fieldbus module used in fieldbus interface diagnoses. These signal the synchronization state between fieldbus interface and drive as well as the bus activity for cyclical data exchange.

| **LED designation** | **LED state** | **Definition** |
|---|---|---|
| H30 | ON | cyclical process data channel active |
| H31 | Impulse | Parameter access |
| H32/H33 | alt. flashing | fieldbus module and drive synchronized |
| H32/H33 | steady flashing | fieldbus module and drive not synchronized |
| All LEDs | flashing regularly | severe error on fieldbus module; switch unit off and on |

Fig. 5-43: Diagnostic LEDs for PROFIBUS X30

## Assigning PROFIBUS Plug-In Connector X30

(See signal assignment X30.PROFIBUS connection in project planning manual).

# 5.3 Command Communications with INTERBUS-S

## General Information

The ECODRIVE03 uses an INTERBUS command communications module that supports protocol

INTERBUS-S with PCP channel, ver. PCP 2.0.

This module makes it possible to transmit both real time data via the process data channel and parameter and data via objects of the PCP, if the master supports PCP communication.

**PCP channel use optional**

To achieve the highest possible flexibility within the system, all process data can be reached via objects which can be allocated to the process data channel as real time data and are thus also cyclically transmittable.

It is also possible to transmit process data via the acyclical channel by using the INTERBUS PCP. However, objects (see also P-0-4081) defined in the real time channel cannot be write accessed by the master via the PCP.

---

**Note:** The use of a master circuit that supports PCP 2.0 (G4) is recommended.

---

## Functional Overview

The INTERBUS-S command module has the following features:

- INTERBUS-S real time channel and PCP 2.0 (G4) channel are supported.
- Configurable process data channel up to 18 words in both data directions. The configuration can be read/write via PCP object 6000 and 6001 or parameter P-0-4080 or P-0-4081 of the drive.
- Process data channel monitored (watchdog function).
- LED diagnosis field on front panel of command module to simplify diagnoses of BUS functions and the most important communications between drive and fieldbus.
- Direct accessing of drive parameters via PCP service R/W.
- Upload/download function for all parameters of the drive including lists of four arrays of 16 to 128 byte data lengths serviced with PCP (Rexroth Indramat SIS protocol).

## INTERBUS-S Interface

The command communications module supports the INTERBUS-S remote bus interface

**Baudrate**

The baudrate of the INTERBUS is exclusively 500 Kbit.

- To ensure EN standards for EMC safety, the INTERBUS interface is completely galvanically decoupled.
- As per DIN 19258, sec. 2, the command module has two 9-pin D-subminiature plug-in connectors for coupling onto the INTERBUS remove bus (incoming and outgoing lines).
- Due to signal coupling (repeater function) and to maintain the BUS function, the module must always be operational.
  The diagnosis of the most important BUS functions can be read out on the LEDs on the front of the module.

## Setting Slave Addresses and Transmission Rates (bus-specific)

**Note:** It is not possible to set either the slave address or the baudrate with INTERBUS!

The baudrate is and must remain 500kBaud. As a result of the ring structure of the INTERBUS, both position and slave address within the ring are fixed. This address is also used with the PCP as CR address (**C**ommunication **R**eference) .

## PCP services

ECODRIVE 03 supports PCP 2.0 version of the Phoenix contact with a 1 word PCP length. Optionally a four-word length can be also be set via P-0-4083.

The use of a master circuit of the G4 group is recommended. However, a G3 master can also be used without restrictions.

**Note:** If the master does not support PCP communications then set **P-0-4083, Length of parameter channel in DP** (PCP-channel width of slave) = 2 in drive. This enlarges the cyclic channel by two bytes. It was specifically prevented, however, that the PCP channel could be switched off by inputting P-0-4083=0 as then the PC free start ups could no always be ensured.

**The following services are supported:**

- **Initiate** establish connection
- **Abort** terminate connection
- **Reject** reject unallowed services
- **Identify** read manufacturer name, type, version
- **Status** read unit/user status
- **Get-OV** read object directory
- **Read** read variable
- **Write** write variable

Additional data and services are listed in the literature of the specific master circuit.

# Object Directory INTERBUS-specific

| Index | Data type | Object type | Access | PD | Object description |
|---|---|---|---|---|---|
| 6000 | PDB | Record | R | no | **P-0-4080, Real-time input object structure** |
| 6001 | PDB | Record | R | no | **P-0-4081, Real-time output object structure** |
| 6002 | Boolean | Variable | R/W | no | Process output data released |
| 6003 | u16 | Variable | R/W | no | Process data monitoring time |

Fig. 5-44: Object directory for INTERBUS

Also, all drive parameters are available via the PCP service R/W (to the extent allowed). The assignment of objects (index and sub-index) on drive parameters is described below.

**Object definition:** The data of an object is accessed via

- Index
- Sub-index

**Generating law for object index:**

- $\text{Index} = 0x2000 + \text{IDN}(S-0-xxxx)$ **S parameters**
- $\text{Index} = 0x3000 + \text{IDN}(P-0-xxxx)$ **P parameters**

**Generating law for object sub-index:** (see also "Bus-Independent Features")

**Example 1**: accessing data of S-0-0051

$\text{Index} = 0x2000 + \text{IDN}(S-0-0051) = 0x2000 + 51 = 0x2033$

attribute = 7, as data accessing is wanted

**Example 2**: accessing data of P-0-0051

$\text{Index} = 0x3000 + \text{IDN}(P-0-0051) = 0x3000 + 51 = 0x3033$

attribute = 7, as data accessing is wanted

# Configuration of INTERBUS Slave

## Configuration of the PCP-channel in the Master

**Needed settings in the master**

The max. object length ("Message Length") must be set to 240 bytes. To do this, the description of the slaves, in the master, must be changed.

**Note:** Using the CMD Tool from Phoenix Contact, this takes place in the context menu of the slave in "Description →Parameter channel →telegram length send and receive".

## Configuration of process data channel

The INTERBUS command communications module makes available to the user an intelligent INTERBUS module that can be configured to meet process demands in the process data section.

The process data is configured independent of the fieldbus type. Usually, the setting of parameter **P-0-4084, profile type** suffices.

The fieldbus can also be used to parametrize by writing the drive parameters over the PCP channel with the SERCOS parameters relevant objects (for assignment see previous section).

The state of this parameter can be read via this object. Further, the INTERBUS-S object 6000/6001, defined in profile 12 (sensor/actuator), can be read via the PCP channel.

However this configuration option requires that the master supports the PCP services.

**Note:** It applies to both the process input data and output data that changes in word length must always lead to modifications in the data stored in the master that were intended for the slave. This is why length changes are not effective until the drive is switched on again. Switching from parametrization into operating does, however, not change the configuration. Instead, a reconfiguration request is sent to the master to tell him that the configuration will change with the next bus reset. This makes a PC free configuration possible.

**P-0-4080, Real-time input object structure (Object 6000)**

The structure and therefore the number of words and their assignment with objects (indices) for the process input data is illustrated in this parameter.
The user can read the existing structure via the PCP read service.

The master can use this configuration to obtain information about the position of the individual objects in the BUS.

**P-0-4081, Real-time output object structure (Object 6001)**

The structure of the process output data is stored here. This means that the current structure and BUS assignment can be read out on the PCP.

**Data direction**

- **Data direction input**

This means slave to master.

- **Data direction output**

This means master to slave.

## Process data input description Object 6000

The process data input description is stored in object 6000. The default configuration example illustrates the structure of this object.

Basic structure:

- The structure of the process data description is fixed in profile 12 of the INTERBUS.
- The length of object 6000 is fixed by the maximum number of words on the BUS.
- The BUS length is entered in bytes (hexadecimal) in the first byte of object 6000.
- The entries for each byte on the bus follow this in rising order. For each byte, an object number (index) must be entered and an additional byte for any sub-index held ready. This byte is always zero!
- If an object is made up of several bytes (standard for ECODRIVE 03 is a word structure of at least two bytes), then the entry for the object number is only for the first byte. The object number for the rest of the bytes is always zero.

**Example:**

| | **Word 1** | **Word 2** | **Word 3** | **Word 4** | **Word 5** | **Word 6** |
|---|---|---|---|---|---|---|
| Data-Out | 6040 | 607A H | 607A L | 6081 H | 6081 L | 5FF1 |
| Data –IN | 6041 | 6064 H | 6064 L | 606C H | 606C L | 5FF6 |

Fig. 5-45: Default configuration in profile type "Interpolation"

| Byte no. | Value | Definition |
|---|---|---|
| 1 | 0x0C | bus length PD in Byte |
| 2 | 0x60 | 1st byte on bus; 6041 |
| 3 | 0x41 | 1st byte on bus; 6041 |
| 4 | 0x00 | sub-index for object 6041 (always 00) |
| 5 | 0x00 | 2nd byte on bus; still for object 6041(word) |
| 6 | 0x00 | 2nd byte on bus; still to object 6041 |
| 7 | 0x00 | sub-index for object 6041 (always 00) |
| 8 | 0x60 | 3rd byte on bus; 6064 H |
| 9 | 0x64 | 3rd byte on bus; 6064 H |
| 10 | 0x00 | sub-index for object 6064 (always 00) |
| 11 | 0x00 | 4th byte on bus; still to object 6064 H (D word) |
| 12 | 0x00 | 4th byte on bus; still to object 6064 H (D word) |
| 13 | 0x00 | Sub-index for object 6064 (always 00) |
| 14 | 0x00 | 5th byte on bus; still to object 6064 L (D word) |
| 15 | 0x00 | 5th byte on bus; still to object 6064 L (D word) |
| 16 | 0x00 | sub-index for object 6064 (always 00) |
| 17 | 0x00 | 6th byte on bus; still to object 6064 L (D word) |
| 18 | 0x00 | 6th byte on bus; still to object 6064 L (D word) |
| 19 | 0x00 | sub-index for object 6064 |
| 20 | 0x60 | 7th byte on bus; object 606C H |
| 21 | 0x6C | 7th byte on bus; object 606C H |
| 22 | 0x00 | sub-index for object 606C |
| 23 | 0x00 | 8th byte on bus; still object 606C (D word) |
| 24 | 0x00 | 8th byte on bus; still object (D word) |
| 25 | 0x00 | sub-index for object 606C |
| 26 | 0x00 | 9th bytes on BUS; still to object 606C L (D word) |
| 27 | 0x00 | 9th bytes on BUS; still to object 606C L (D word) |
| 28 | 0x00 | Sub-index for object 606C |
| 29 | 0x00 | 10th byte on bus; still to object 606C L |
| 30 | 0x00 | 10th byte on bus; still to object 606C L |
| 31 | 0x00 | sub-index for object 606C |
| 32 | 0x5F | 11th byte on bus; object 5FF6 (word) |
| 33 | 0xF1 | 11th byte on bus; object 5FF6 (word) |
| 34 | 0x00 | sub-index for object 5FF6 |
| 35 | 0x00 | 12th byte on bus; still to object 5FF6 |
| 36 | 0x00 | 12th byte on bus; still to object 5FF6 |
| 37 | 0x00 | sub-index for object 5FF6 |

Fig. 5-46: Object 6000 Process input data

## Process data output description object 6001

The process data output description is stored in object 6001. It contains position and number of output words on the BUS.
The structure corresponds complete to the process input data description in object 6000, but with the relevant objects.

The description relates to the following default configuration for the profile type "Interpolation".

**Example:**

| | Word 1 | Word 2 | Word 3 | Word 4 | Word 5 | Word 6 |
|---|---|---|---|---|---|---|
| Data-Out | 6040 | 607A H | 607A L | 6081 H | 6081 L | 5FF1 |
| Data –IN | 6041 | 6064 H | 6064 L | 606C H | 606C L | 5FF6 |

Fig. 5-47: Default configuration in profile type "Interpolation"

| Byte no. | Value | Definition |
|---|---|---|
| 1 | 0x0C | Bus length PD in Byte |
| 2 | 0x60 | 1st byte on bus; 6040 |
| 3 | 0x40 | 1st byte on bus; 6040 |
| 4 | 0x00 | Sub-index for object 6040 ( always 00) |
| 5 | 0x00 | 2nd byte on bus; still to object 6040 (Word) |
| 6 | 0x00 | 2nd byte on bus; still to object 6040 |
| 7 | 0x00 | Sub-index for object 6040 (always 00) |
| 8 | 0x60 | 3rd byte on bus; 607A H |
| 9 | 0x64 | 3rd byte on bus; 607A H |
| 10 | 0x00 | Sub-index for object 607A (always 00) |
| 11 | 0x00 | 4th byte on bus; still to object 607A H (D word) |
| 12 | 0x00 | 4th byte on bus; still to object 607A H (D word) |
| 13 | 0x00 | Sub-index for object 607A (always 00) |
| 14 | 0x00 | 5th byte on bus; still to object 607A L (D word) |
| 15 | 0x00 | 5th byte on bus; still to object 607A L (D word) |
| 16 | 0x00 | Sub-index for object 607A (always 00) |
| 17 | 0x00 | 6th byte on bus; still to object 607A (D word) |
| 18 | 0x00 | 6th byte on bus; still to object 607A (D word) |
| 19 | 0x00 | Sub-index for object 607A |
| 20 | 0x60 | 7th byte on bus; Object 6081 H |
| 21 | 0x6C | 7th byte on bus; Object  081 H |
| 22 | 0x00 | Sub-index for object 6081 |
| 23 | 0x00 | 8th byte on bus; still object 6081 H (D word) |
| 24 | 0x00 | 8th byte on bus; still object 6081 H (D word) |
| 25 | 0x00 | Sub-index for object 6081 |
| 26 | 0x00 | 9th Byte am BUS; still to object6081 L (D word) |
| 27 | 0x00 | 9th Byte am BUS; still to object6081 L (D word) |
| 28 | 0x00 | Sub-index for object 6081 |
| 29 | 0x00 | 10th byte on bus; still to object 6081 L |
| 30 | 0x00 | 10th byte on bus; still to object 6081 L |
| 31 | 0x00 | Sub-index for object 6081 |
| 32 | 0x5F | 11th byte on bus; Object 5FF1 (Word; Dummy) |
| 33 | 0xF1 | 11th byte on bus; Object 5FF1 (Word; Dummy) |
| 34 | 0x00 | Sub-index for object 5FF1 |
| 35 | 0x00 | 12th byte on bus; still to object 5FF1 |
| 36 | 0x00 | 12th byte on bus; still to object5FF1 |
| 37 | 0x00 | Sub-index for object 5FF1 |

Fig. 5-48: Object 6000 process output data

# Length of process data channel in the ECODRIVE 03

The INTERBUS slave circuits permits a flexible configuration of the process data channel. The entire cyclical data channel for input and output data is defined as the process data channel. Within the process data channel both the parameter channel (optional) and the real time channel in which the drive's cyclical data are transmitted, are located.

The length of the process data channel depends on what is set in **P-0-4084, profile type**. In the freely configurable profile types (P-0-4084 = 0xFFFE) user-specific expansions of the process data channel can mean that drive controllers are operated with different lengths of the process data channel for the I/O directions.

---

**Note:** Dummy bytes (P-0-4076) are automatically added in this case to make the lengths equal.

---

The process data channel can only have words or double words not bytes as a data type. The lengths are fixed in bytes in terms of the compatibility to other bus systems.

**Length of the PD channel**

The length of the process data channel must equal

1... 9 words or 2...18 bytes

in both directions with the same lengths.

## Setting the length of the PD channel in the ECODRIVE 03

The length of the PD channel corresponds to the contents of the configuration lists in P-0-4080 or P-0-4081 and can be read out of parameters

- **P-0-4082, Length of real-time data channel In**
- **P-0-4087, Length of real-time data channel Out**

The setting is accepted when the drive controller is run up into operating mode.

---

**Note:** Any change in the length of the process data also means a change in the configuration of the master. The length of the process data channel must agree with the projected length in the master.

---

With INTERBUS it applies: **P-0-4082 = P-0-4087!**

The length set in the SERCOS parameters P-0-4082 or P-0-4087 is accepted directly by the INTERBUS slave circuit into objects 6000 and 6001 so that it is also possible to read out the configuration via the PCP.

**ID Code** the ID code of the INTERBUS interface depends on profile type (P-0-4084) and width of PCP channel set (compare P-0-4083).

| PCP-channel width (P-0-4083) in Bytes | Length cyclic channel (P-0-4082) | ID code | INTERBUS length code |
|---|---|---|---|
| 2 | 4 | 0xF3 | 0x02 |
| 2 | 6 | 0xF3 | 0x03 |
| 2 | 8 | 0xF3 | 0x04 |
| 2 | 10 | 0xF3 | 0x05 |
| 2 | 12 | 0xF3 | 0x0E |
| 2 | 14 | 0xF3 | 0x0F |
| 2 | 16 | 0xF3 | 0x06 |
| 2 | 18 | 0xF3 | 0x07 |
| 8 | 10 | 0xF1 | 0x05 |
| 8 | 12 | 0xF1 | 0x0E |
| 8 | 14 | 0xF1 | 0x0F |
| 8 | 16 | 0xF1 | 0x06 |
| 8 | 18 | 0xF1 | 0x07 |
| 8 | 20 | 0xF1 | 0x15 |
| 8 | 22 | 0xF1 | not possible |
| 8 | 24 | 0xF1 | 0x16 |

Fig. 5-49: Overview of ID codes in the INTERBUS-S

**Note:** If a four word PCP is set, then neither an 18 nor a 14 byte length in the real-time channel is possible (P-0-4082 and P-0-4087).

**Note:** For cyclic channel lengths (P-0-4082) of 12, 14, 20 and 24 bytes the master needs a firmware version starting with 3.2.

## Diagnostic LEDs for INTERBUS

The LEDs on the INTERBUS of the DKC04.3 meet the requirements for an INTERBUS certification.

| | LED designation | LED status | Definition |
|---|---|---|---|
| Remote Check | H40/RC | green | command cable OK |
| Bus Active | H41/BA | green | data exchange active |
| Transmit/Receive | H42/TR | green | PCP transmission active |
| Remote Bus Disable | H43/RD | red | continuing remote bus segments off |
| | H44 | green flashing (1 Hz) | Communication fieldbus drive OK |
| | H44 | red flashing (1 Hz) | communication fieldbus drive not synchronous |
| Module status | H44 | red | Initialization failed. Module defective. |
| Reconfiguration | H44 | as "Module status" but 2 Hz | as long as reconfiguration request is pending in slave, the LED flashes at twice the rate |
| Operating LED | H45/UL | green | voltage source OK |
| Severe fieldbus module error | H40, H42, H42, H44 H45 | red flashing red | severe error on fieldbus module, switch unit off and on again. |

Fig. 5-50: Diagnostic LED for INTERBUS

## Assignment INTERBUS-S - connectors X40 / X41

(See signal assignment X40 / X41, INTERBUS Interface, Incoming / Outgoing Interface in project planning manual).

# 5.4 Command communications with CANopen

## General Information

A CANopen communications module is available for use by an ECODRIVE03. It supports protocol

- **CANopen per DS301 version 3.0**

**PDO and SDO** With this module it is possible to transmit both real time data via the so called process data objects (PDO) and parameters and data via the Service data objects (SDO) of the CANopen services.

**Note:** The real time data are always transmitted with PDO.

To achieve the greatest possible system flexibility, all data can be reached via objects. These objects can be allocated as real time data to the process data channel and thus also be cyclically transmitted. The option of transmitting via an acyclical channel with SDO is also possible, but the master may not write access any of the objects (see also P-0-4081) defined in the real time channel.

# Functional Overview

The CANopen command communication module has the following features:

- Simple configuration due to the use of predefined connection set and boot-up per DS301
- The baudrates specified by CANopen (per DS301) of 20, 50, 100, 125, 250, 500 kbps and 1 Mbps, except for 800 kbps, are supported.
- Freely configurable process data channel but not with up to 9 words in both data directions via SERCOS parameters of the drive.
- Downwardly compatible to PROFIBUS functions of ECODRIVE01 possible with profile selection (I/O mode).
- Monitoring of the process data channel (watchdog function)
- Diagnostic LEDs on the front of the module for simple diagnoses of BUS functions and important communications relationships between drive and fieldbus.
- All parameters of drive can be read direct via SDO and written to also (if this is allowed).
- Upload/download function for all parameters of the drive lists including four arrays of 16 to 128 byte data length with SDO services possible (Rexroth Indramat SIS protocol).
- Event controlled transmission of real time data can be switched off (default = not event controlled)

# CANopen Interface

The command communication module supports

**CANopen specification per DS301**

- To ensure EN standards for EMC safety, the CANopen interface is completely galvanically decoupled.
- As per DS301 the command communications module has a 9 pin D-subminiature connector to couple to the bus. Assignment corresponds to DS301.

# Setting the Slave Address and Transmission Rates (bus-specific)

## Adressing the CANopen slave

**Prioritization**

The address determines the priority of the slave message whereby the lowest address has the highest priority. Generally, the master has the highest priority and thus the lowest address.

**Predefined Connection Set**

Each CANopen subscriber on the bus must send those messages that are allocated to him. As per **Predefined Connection Set** of DS301a bus-wide unequivocal address of the slave is thus necessary. This address is set on the inserted firmware module.

---

**Note:** As per CANopen an address in the range of 1..127 can be set. With a DKC05.3 it is only possible to set addresses up to 99 maximum. Address 0 not allowed.

---

## SDO Services

DKC05.3 supports the messages defined in **Predefined Connection Set** of CANopen DS301:

This defines the following message identifiers(COB-ID):

| COB ID | Definition |
|---|---|
| 0x000 | NMT, Master → DKC05.3 |
| 0x080 | SYNC, Master → DKC05.3 |
| 0x080 + address | EMCY, DKC05.3 → Master |
| 0x180 + address | PDO1, DKC05.3 → Master |
| 0x200 + address | PDO1, Master → DKC05.3 |
| 0x280 + address | PDO2, DKC05.3 → Master |
| 0x300 + address | PDO2, Master → DKC05.3 |
| 0x380 + address | PDO3, DKC05.3 → Master |
| 0x400 + address | PDO3, Master → DKC05.3 |
| 0x580 + address | SDO, DKC05.3 → Master |
| 0x600 + address | SDO, Master → DKC05.3 |

Fig. 5-51: Message identifier (COB-ID)

For further information about services, see the literature of the master circuit.

## Electronic Data Sheet for DKC05.3

For each **CANopen unit** there must be an EDS file **(*.EDS**) in which the data needed to operate the unit on the BUS are stored. This file is needed for the configuration of the BUS master for each participant.

**File name:** The EDS file for an ECODRIVE03 is an ASCII file designated with

**DKC05P3.EDS**

All the objects in the unit are described in this EDS file.

**Note:** The EDS file is stored at installation of DriveTop in directory "Indramat\ Device Data Sheets".

## Object Directory CANopen specific

The communications objects defined by CANopen in DS301 are made available here.

All drive parameters can be read/write via SDO (service data object).

To make acyclic accessing easy, the objects (index and sub-index) were allocated to drive parameters. This is described below:

**Object definition** The data of an object is accessed via

- Index
- Sub-index

**Generating law for object index:**

- $\text{Index} = 0x2000 + \text{IDN}(S-0-xxxx)$ S parameters
- $\text{Index} = 0x3000 + \text{IDN}(P-0-xxxx)$ P parameters

**Generating law for object sub-index:**

(See also "Bus-Independent Features)

**Example 1**: accessing data of S-0-0051

$\text{Index} = 0x2000 + \text{IDN}(S-0-0051) = 0x2000 + 51 = 0x2033$

attribute = 7 (or 10), as data accessing is wanted

**Example 2**: accessing data of P-0-0051

$\text{Index} = 0x3000 + \text{IDN}(P-0-0051) = 0x3000 + 51 = 0x3033$

attribute = 7 (or 10), as data accessing is wanted

# Configuration of CANopen Slave

## Configuration of the process data channel (PDO)

The process data are configured independent of the fieldbus type.

With the CANopen command communication module the user has at his disposal an intelligent module configured to correspond to process demands.

The setting in **P-0-4084, profile type** generally also configures the process data channel (real time data channel).

---

**Note:** Profile types P-0-4084 = 0xFFFE or 0xFF82 are an exception. The user can configure this profile type.

---

see also "Profile types".

Parametrization can use the fieldbus in which the drive parameters can be write accessed using the data exchange objects via the SDO.

The values of this parameters can also be read via the data exchange objects. Alternately, it is possible to read via the SDO, the in DS301 defined PDO mapping objects 1600/1A00.

The configuration entered in parameters P-0-4080 and P-0-4081 is accepted in operating mode when the drive is run up.

**P-0-4080, Real-time input object structure**
**PDO mapping objects 1A00, 1A01, ...**

The structure of the PDO sent from slave to master is described here as well as the length and assignment of the PDO with objects (indices) for the process input data.

The user can read out any existing structures via the SDO read services.

The master can use this configuration to know which object is transmitted into which PDO at which location.

---

**Note:** Up to 32 PDO can be configured with 8 byte length in both data directions.

---

**P-0-4081, Real-time output object structure PDO mapping objects 1600, 1601, ...**

The structure of the process output data is stored here (master→slave). The current structure can be read out here via SDO along with the assignment of the PDO.

**Note:** It applies to both the process input data and output data that changes in word length must always lead to modifications in the data stored in the master that were intended for the slave. This means that PDO changes are not accepted until the drive is switched off or the phase switched from parametrization to operating mode.

**Data direction**

- **Data direction input**

This means slave to master.

- **Data direction output**

This means master to slave.

## Number and length of PDO in ECODRIVE 03

The CANopen slave circuit permits a flexible configuration of the process data channel. The process data channel in CANopen is broken down into PDO process data objects.

Length and number of PDOs depend on what is set in **P-0-4084, profile type**. It is also possible with the freely-configurable profile types (P-0-4084 = 0xFFFE) to make user-specific expansions in the process data channel meaning that the drives can operate with different PDO configurations.

Since all data of the drive are at least two bytes long a PDO can only contain a word or a double word, not bytes as data types. The lengths are fixed by the compatibility to other bus systems in bytes.

The configuration of length is generally automatic and determined by the profile type.

**Note:** A double word may never be divided into 2 PDOs.

**Length of the PD channel P-0-4082, P-0-4084**

The length of the process data channel can presently equal (max. 3 PDO)

2...18 bytes

for both directions separately.

The transmission is data consistent over the entire length.

## Diagnoses LED for CANopen

For fieldbus interface diagnoses there are six LEDs on the front of the fieldbus module. These signal the state of synchronization between fieldbus interface and drive as well as bus activity for cyclical data exchange.

Each LED can accept any of the four states, namely, red, green, orange and off .

When running up the CANopen module, the LEDs are automatically tested which can be seen by the glowing the various colours.

LED definition when module in operation:

| | **LED design** | **LED state** | **Definition** |
|---|---|---|---|
| Initialization | H50 | red | Initializing failed, module defective |
| | | green | module OK |
| operating LED | H51 | red | Operating error (Bus off).<br>Too many errors on bus detected.<br>Possible causes:<br>⇨ wrong baudrate<br>⇨ cable defective |
| | | green | operation OK |
| SDO query | H52 | green (impulse) | an SDO was received |
| SYNC | H53 | green | SYNC news is being received<br>The LED is green each time a SYNC arrives for 200ms. In the otherwise high frequency, the LED is continuously illuminated. |
| | | off | no SYNC being received |
| internal synchronization<br>(Alive LED) | H54 | red flashing | no synchronization of fieldbus module with drive |
| | | green flashing | Synchronization of fieldbus modules with drive established |
| PDO data | H55 | green | PDO real time transmission active. The green LED is switched on for 20 ms with each PDO. Generally, it is always lit up at these high frequencies. |
| Severe fieldbus module error | All LEDs | flashing regularly | Severe error on fieldbus module. Unit must be switched off and on. |

Fig. 5-52: Diagnoses for LED for CANopen

## Assignment of CANopen Connectors X50

The 9-pin D-subminiature connector meets CANopen standard DS102 and has the following signal assignment:

(See signal assignment X50 in project planning manual).

# 5.5 Command communications with DeviceNet

## General Information

The ECODRIVE03 has a DeviceNet command communications module available to it which supports protocol

- DeviceNet per ODVA version 2.0.

With this module, both **real time data** can be transmitted via so-called **Polled I/Os** as well as drive parameters via an **Explicit Message** of the DeviceNet.

**Note:** The real time data are always transmitted with polled I/Os.

To achieve the greatest possible system flexibility, all data can be reached via objects. In DeviceNet these objects can be addressed via class, instance and attribute. Some of these objects can be assigned as real time data to the polled I/Os and thus cyclically transmitted. The option of transmitting via Explicit Message is also given, but no object defined by the master may be transmitted in the real-time channel (P-0-4081, Process data channel output) via Explicit Message.

## Functional Overview

The DeviceNet command communication module has the following features:

- DeviceNet **General Device** per specification **ODVA 2.0.**
- Easy configuration by using **Group 2 only Server.**
- Support of all data rates: **125, 250 and 500 kbps.**
- Free configurable process data channel up to 9 words in data directions via the SERCOS parameters P-0-4080 and P-0-4081 of the drive.
- Supplementary similar functions in comparison to other command communications modules of the ECODRIVE03.
- Monitoring of process data channel (Watchdog function).
- LED diagnostic field in front panel of command communications module for easy diagnoses of BUS functions and the most important communications relationship between drive and fieldbus.
- All parameters of the drive are directly write accessible via Explicit Message and (if allowed) can be write accessed also.
- Upload/download function for all drive parameters including lists over four arrays of 16 to 128 byte data lengths with Explicit Message services possible (Rexroth Indramat -SIS protocol).
- **Open Pluggable Connector** corresponds to ODVA Spec. 2.0.

## DeviceNet Interface

The command communication module supports

**DeviceNet specification per ODVA 2.0**

- To ensure standard EMC safety, DeviceNet interface completely galvanically separated.
- As per ODVA specification 2.0, communications module has a Phoenix Combicon plug (Open Pluggable Connector) to connect to bus.

## Setting the Slave Address and Transmission Rates (bus-specific)

### Addressing the DeviceNet slave

The address determines priority of messages from slave, whereby the lowest address has highest priority. Generally, the master has highest priority and thus the lowest address.

**MacId** Each DeviceNet participant must send to the bus messages clearly allocated to him. Per DeviceNet specification this requires a bus-wide address (MacId) for the slave. This address is set on the inserted firmware module.

---

**Note:** Per ODVA 2.0 addresses ranging from 1 to 63 can be set. In DKC06.3 addresses up to maximum 99 can be set. Invalid addresses are treated as if they were address 63.

---

## Explicit Message

The DKC06.3 is a Group 2 only server and supports acyclic data exchange via Explicit Message (see object directory).

For further information about services, see the literature of the master circuit.

## Electronic Data Sheet for DKC06.3

For each DeviceNet unit there must be an EDS file (*.EDS) in which the data needed to operate the unit on the BUS are stored. This file is needed for the configuration of the BUS master for each participant.

**File name:** The EDS file for an ECODRIVE03 is an ASCII file designated with

**DKC05P3.EDS**

All the objects in the unit are described in this EDS file.

---

**Note:** The EDS file is stored at installation of DriveTop in directory "Indramat\ Device Data Sheets".

---

# Object Directory DeviceNet specific

The communications objects as defined by DeviceNet in ODVA specification 2.0 are made available.

The imaging of SERCOS parameters on objects (class, instance and attribute) of all drive parameters (Parameter block 0 ) that can be R/W via Explicit Message. They are addressed via a direct conversion of the SERCOS parameter number in the object with:

- class
- instance
- and attribute

## Generating law for object class:

S parameters are imaged in classes 101 to 117 :

- $\text{class} = 101 + [\text{IDN}(\text{S}-0-\text{xxxx}) - 1] / 255$ **S parameters**

P parameters are imaged in classes 133 to 164 :

- $\text{class} = 118 + [\text{IDN}(\text{P}-0-\text{xxxx}) - 1] / 255$ **P parameters**

with $\text{S}-0-\text{xxxx}$ or P-0-xxxx: parameter ID number

## Generating law for object instance:

- $\text{Instance} = \text{IDN}(\text{S}-0-\text{xxxx}) - [(\text{class} - 101) \cdot 255]$ S parameters
- $\text{Instance} = \text{IDN}(\text{P}-0-\text{xxxx}) - [(\text{class} - 118) \cdot 255]$ P parameters

with $\text{S}-0-\text{xxxx}$ or $\text{P}-0-\text{xxxx}$: parameter ID number

Generating law for object attribute: with the attribute it is possible to address the parameter elements:

The assignment of attributes is described in the fieldbus section.

**Example 1**: accessing data of S-0-0051

$$\text{class} = 101 + [\text{IDN}(\text{S}-0-0051) - 1] / 255 = 101 + 50/255 = 101$$

$$\text{Instance} = \text{IDN}(\text{S}-0-0051) - [(\text{class} - 101) \cdot 255] = 51 - 0 \cdot 255 = 51$$

attribute = 7 (or 10) as data can be accessed

**Example 2**: accessing data of P-0-0051

$$\text{class} = 118 + [\text{IDN}(\text{S}-0-0051) - 1] / 255 = 118 + 50/255 = 118$$

$$\text{Instance} = \text{IDN}(\text{P}-0-0051) - [(\text{class} - 118) \cdot 255] = 51 - 0 \cdot 255 = 51$$

attribute = 7 (or 10) as data can be accessed

## Data exchange objects

The data exchange objects support the access of parameter blocks >0 (feedback memory, gearbox stages).

### The assembly object

The data of the polled I/O are exchanged via the assembly object

instance 1 = output object

and

instance 2 = Input Object.

Attribute 3 contains the drive objects configured in the real time channel.

Additionally, attributes 1+2 can be read out per ODVA Spec. 2.0 with the help of the configuration of the assembly object using a DeviceNet diagnostics tool.

| | | |
|---|---|---|
| attribute 1: | UINT16 | number of data objects in assembly |
| attribute 2: | ARRAY of STRUCT | list of data objects in assembly |

Structure definition:

| | |
|---|---|
| UINT16 | size of object in bits |
| UINT16 | size of object description in bytes |
| ARRAY of BYTE | symbolic object path class/instance/attribute |

## Configuration of DeviceNet Slave

### Configuration of the process data channel (Polled I/O)

The process data (Polled I/O) are configured independent of the fieldbus type.

The setting of **P-0-4084, Profile type** often includes a configuration of the polled I/O (real time data channel).

---

**Note:** The profile types P-0-4084 = 0xFFFE or 0xFF82 is an exception in this case. In this case the user sets the profile type of the configuration.

---

Also see section “Profile Type”.

It is possible to parametrize via the fieldbus also by writing the drive parameters using Explicit Message.

The programmed values of this parameter can also be read via Explicit Message. The assignment of the polled I/O can also read via attribute 2 of the relevant Assembly Objects per ODVA spec. 2.0 via Explicit Message.

The configurations entered in the parameter is assumed in operating mode when the drive runs up.

### P-0-4080, Process data input description

**Input Assembly Class 4, Instance 2, attribute 1+2**

In this object, the structure of the data sent from slave to master is descripted in the polled I/O as well as the assignment with objects (Class/Instance/Attribute) for the process input data.
The user can read the existing structure via the read service of Explicit Message.

The master can use this configuration in order to understand which object is being transmitted at which position of the polled I/O.

### P-0-4081, Process data output description

**Output Assembly Class 4, Instance 1, attribute 1+2**

The structure of the polled I/O from master to slave is stored in this object. Thus the current structure and the assignment of the polled I/O can be read via Explicit Message Read.

**Note:** Both for the process input data and output data it applies that changes in the data length always require a modification of the data stored in the master for the slave. Thus any changes in these values are not effective until the drive has been switched off and on or after phase transition from parametrization into operating modes.

**Data direction**

- **Data direction input**

The data direction input is the data transmission from slave to master.

- **Data direction output**

This is direction from master to slave.

**Note:** Up to 18 bytes of data (including fieldbus control word, fieldbus status word) can be configured per data direction.

## Number and length of Polled I/O in DKC06.3

The DeviceNet slave connection permits a flexible configuration of the polled I/O.

The length of polled I/O depends on what was set in **P-0-4084, Profile type**. Additionally, in free configurable profile types (P-0-4084 = 0xFFFE or 0xFF82) user-specific expansions of the process data channel can mean that the drive controllers are run with differently polled I/Os.

As all data of the drive controller are at least two bytes in size, the polled I/O can only contains words or double words, not bytes as data types. The length specification is in bytes because of compatibility to other bus systems.

The configuration of length is generally automatic and specified by the operating mode.

**Length of PD-channel P-0-4082, P-0-4087**

The length of the process data channel is present 2...18 bytes for each direction and must be entered separately.

The transmission is data consistent over the entire length.

## Diagnose-LED for DeviceNet

To diagnose fieldbus interfaces, there are 6 LEDs on the front side of the DeviceNet module. these LEDs signal the status of synchronization between fieldbus interface and drive as wll as bus activity for the cyclic exchange of data.

Each LED can use the four states "off", "red", "green" and "orange".

During run up of DeviceNet module, the LEDs are tested. This takes the form of a running light in the colours red, green and orange.

LED definition in module operation:

| | **LED design** | **LED state** | **Definition** |
|---|---|---|---|
| not assigned | H60 | | |
| Module status | H61/MS | red | fatal error, replace card |
| | | red flashing | error can be cleared |
| | | green flashing | configuration error |
| | | green | ready OK |
| Explicit Message query | H62 | green (impulse) | in R/W via Explicit Message |
| Network status | H63/NS | off | not online |
| | | green flashing | online, but no connection to master |
| | | green | online master connected |
| | | red flashing | in I/O connection monitoring time exceeded |
| | | red | critical connection error (doubled MAC-ID or Bus-Off |
| internal synchronization<br>(Alive LED) | H64 | red flashing | no synchronization of fieldbus module with drive |
| | | green flashing | synchronization of fieldbus module with drive established |
| I/O status | H65/IO | off | no I/O connection |
| | | green | I/O connection OK, outputs valid and input active |
| | | green flashing | outputs inactive (not sent by master) |
| | | red flashing | in I/O connection, monitoring time exceeded |
| Severe fieldbus module failure | all LEDs | flashing regularly | Severe fieldbus module failure, switch unit off and on. |

Fig. 5-53: Diagnosis LED for DeviceNet

# 6 Profile Types

## 6.1 General Introduction

### Overview of the Profile Types Supported

| P-0-4084, Profile type | Drive controller | Function compatibility | Fieldbus or drive operating mode | Description |
|---|---|---|---|---|
| **I/O profile types** | | | | |
| **FF80h** | DKC03.3-xxx-7-FW<br>DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW<br>DKC06.3-xxx-7-FW | PDP03VRS(1)<br>FGP01VRS(2)<br>FGP02VRS(3) | **I/O mode with block acknowledge** (Positioning block mode lag error free with encoder 1) | This profile type makes functional compatibility to control (**DKC3.1**) possible with up 64 positioning block via the fieldbus. 16 bits each for I/O data are transmitted. |
| **FF81h** | DKC03.3-xxx-7-FW<br>DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW<br>DKC06.3-xxx-7-FW | FGP02VRS | **I/O mode** with cam status (Positioning block mode lag error free with encoder 1) | This profile type makes it possible, as with P-0-4084=0xFF80, to control up to 64 positioning blocks via the fieldbus. But instead of the travel block acknowledge, the first 8 cam status bits are stored in the status word. |
| **FF82h** | DKC03.3-xxx-7-FW<br>DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW<br>DKC06.3-xxx-7-FW | FGP02VRS | **I/O mode** free expandable (pos. block mode lag free with encoder 1 + expandable real time data channel) | This profile type makes it possible, as with P-0-4084=0xFF80, to control up to 64 positioning blocks via the fieldbus. But in addition to control and status words, more real time data can be configured in lists P-0-4080 and P-0-4081. The function of the bits in the fieldbus status words can be freely configured via the config. signal status word. |
| **Rexroth Indramat – specific profile types** | | | | |
| **FF91h** | DKC03.3-xxx-7-FW<br>DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW<br>DKC06.3-xxx-7-FW | FGP02VRS | drive internal interpolation (lag free with encoder 1) | This profile type makes cyclic settings of freely selectable target positions and velocities possible. All real time data needed for execution are pre-configured in lists P-0-4080 and P-0-4081. Control and status words have the same structure as in free config. operating mode (0xFFFE) |
| **FF92h** | DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW | FGP02VRS | cyclic position control (lag free with encoder 1) | This profile needs clock-synchronous and cyclic transmission of position setpoints in „cyclic position control“ modes. All real time data needed are pre-configured in lists P-0-4080 and P-0-4081. Control and status words have the same structure as in free config. operating mode (0xFFFE). |
| **FF93h** | DKC03.3-xxx-7-FW<br>DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW<br>DKC06.3-xxx-7-FW | Function compatible to profile type velocity control 2 | velocity control (with filter and ramp) | This profile makes cyclic setting of velocity setpoints in „velocity control“ mode possible. All real time data needs are pre-configured in lists P-0-4080 and P-0-4081. Control and status words have same structure as free config. operating mode (0xFFFE). |
| **FFFEh** | DKC03.3-xxx-7-FW<br>DKC04.3-xxx-7-FW<br>DKC05.3-xxx-7-FW<br>DKC06.3-xxx-7-FW | FGP02VRS (makes possible function compatibility to profile position target setting) | Free configurable mode (without profile interpreter) | This profile allows free configuring of real time data as well as selection of operating mode possible, i.e. access to all drive functions! Control and status word have an Indramat-specific structure. This choice is also suited for operation with analog setpoints in commissioning phase. |

Fig. 6-1: Supported profile types: FWA-ECODR3-FGP-03VRS

Complete designations of firmware:

(1) FWA-ECODRV-PDP-03VRS-MS

(2) FWA-ECODR3-FGP-01VRS-MS

(3) FWA-ECODR3-FGP-02VRS-MS

# Definitions

### Drive profiles

A drive profile defines

- the structure of fieldbus control and status words (**P-0-4077**, **P-0-4078**)
- the structure and contents of real time channel (**P-0-4080**, **P-0-4081**)
- active operating mode (**S-0-0032**, **S-0-0033**, **S-0-0034**, **S-0-0035**)
- the behavior of any present status machines (I/O mode or Rexroth Indramat status machines).

By selecting a profile type, the commissioning of fieldbus drives becomes very easy for the user. The advantage of a profile is that the selection of all the important settings for the desired drive functions can be performed automatically. As profile types are defined independent of the bus, the porting of applications from one fieldbus to the next also becomes easy.

### Status machines

A state (e.g., drive halt, drive error and so on) represents a specific drive condition which can be exited by means of a defined event (e.g., drive command, operating mode commutations and so on). State transitions are assigned to the events. The interaction of control and status bits as well as the state transitions is defined as a status machine.

### Intel/ Motorola format

(see section: "Command communication via fieldbus")

### Abbreviations

- **i16**: 16 bit variable with sign(1 word) in Intel format
- **i32**: 32 bit variable with sign(2 words) in Intel format
- **u16:** 16 bit variable without sign(1 word) in Intel format
- **u32**: 32 bit variable without sign(2 words) in Intel format
- **ZKL1:** Status class 1
- **ZKL2**: Status class 2
- **ZKL3**: Status class 3

# Allocation to Drive-Internal Modes

By setting a profile type (P-0-4084) the main operating mode in the drive is also set!

## Operating modes used

The following relationship exists between

**P-0-4084, Profile type** and **S-0-0032, Primary mode of operation**:

- **I/O mode** with 16 bit status and control word
  (P-0-4084=0xFF80 → functionally compatible to DKC3.1! )
  This means that the drive is run in “Positioning block mode without lag error with encoder 1”!
- **Position control** with cyclic position setpoint ( DKC4.3, DKC5.3)
  This means the drive is run in “Cyclic position control without lag error with encoder 1"!
- **Drive-internal interpolation**
  This means that the drive is run in “Drive internal interpolation without lag error with encoder 1".
- **Velocity control**
  This means the drive is run in “Velocity control mode”.
- **Free configurable modes**
  - no profile-dependent settings and checks
  - free configuration of real time channel using configuration lists P-0-4080 and P-0-4081
  - makes analog operation for initial start up possible

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**Note:** In all settings except free configurable mode, the 1st auxiliary operating mode is automatically “jogging”. To use it, the auxiliary operating mode (generally 1st aux. mode) must also be selected.

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# 6.2 I/O Mode

## Basic I/O mode function

### General features of I/O modes

- The drive is run in “positioning block mode, lag free with encoder 1”.
- In this mode, up to 64 programmable positioning blocks can be selected and started via 6 bits in the 16 bit wide control word (known from DKC3.1).
- Via 2 bits in **P-0-4077, fieldbus control word** the jog function can be activated. As 1st auxiliary mode, jog mode has been set!
- In a DKC03.3 (Profibus-DP) an optional parameter channel with **P-0-4083, Length of parameter channel in DP** (maximum 6 words) can be activated. (Default: **P-0-4083** = 0 → without parameter channel).
- In I/O mode the real time channel is made up of one word (16 bits), of **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word.**

### Structure of real time channel in I/O mode

**Master → Slave**

In real time channel of fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive:

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | I16 -> (1 word) |

**Slave → Master**

In real time channel of fieldbus, data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | I16 -> (1 word) |

**Sequence of data in real time data channel:**

| | Word1 |
|---|---|
| Master → Slave | **P-0-4077, Fieldbus control word** |
| Slave → Master | **P-0-4078, Fieldbus status word** |

Fig. 6-2: Contents of real time channel in I/O mode

# Status machine in I/O mode (Fieldbus control and status word)

## Structure of P-0-4077, Fieldbus control word (P-0-4084 = 0xFF8X)

**Note:** The structure of **P-0-4077, Fieldbus control word** is identical in all three possible I/O modes (P-0-4084 = 0xFF80, 0xFF81 and 0xFF82).

| Bit | Assignment | Description |
|---|---|---|
| **0** | drive enable | **1:** drive enable<br>**0:** drive lockout (**S-0-0134**, Bit14) |
| **1** | drive start | **1:** drive start<br>**0:** drive halt (**S-0-0134**, Bit13) |
| **2** | drive-controlled to zero (referencing) | **1:** command "C6" start (**S-0-0148** = 11b)<br>**0:** command "C6" end (**S-0-0148** = 0b) |
| **3** | strobe | **0>1:** travel block change (**S-0-0346**) |
| **4** | positioning with limited velocity | **1:** limited velocity with **S-0-0259, Positioning Velocity** as limit |
| **5** | reset error (F-Reset) | **1:** reset error command "C5" start (**S-0-0099, C500 Reset class 1 diagnostic**)<br>**0:** command "C5" end |
| **6** | Jog + | **1:** jog forward (**P-0-4056**, Bit0) with **P-0-4030, Jog velocity** |
| **7** | Jog - | **1:** jog backwards (**P-0-4056**, Bit1) with **P-0-4030, Jog velocity** |
| **8-13** | travel block select | **P-0-4026, Process block selection** (Bit 0 – Bit6) |
| **14-15** | not assigned | |

Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode

## Structure of P-0-4078, fieldbus status word (P-0-4084 =0xFF8X)

- Structure of **P-0-4078, Fieldbus status word** is in all three I/O modes (P-0-4084 = 0xFF80, 0xFF81 and 0xFF82) the same as **S-0-0144, Signal status word**. Here, the structure of S-0-0144 (and P-0-4078) with P-0-4084 = 0xFF80 and P-0-4084=0xFF81 is permanently pre-configured.
- Only in freely expandable I/O mode (P-0-4084=0xFF82) can the structure be selected via configuration list **S-0-0026, Configuration list signal status word** and **S-0-0328, Assign list signal status word**.
- The profile types for P-0-4084=0xFF80 (I/O mode with block acknowledge) and P-0-4084=0xFF81 (I/O mode with cam status) are only different in terms of the definition of bits 0 and 1 and from bit 8 to bit 15. (see structure of P-0-4078)**.**

| Profile type | Bit | Assignment | Description |
|---|---|---|---|
| P-0-4084=0xFF80 | **0** | active mode<br>(in 0xFF80) | **1:** jog<br>**0:** positioning |
| | **1** | point of removal (WSP)<br>(in 0xFF80) | **1:** to the right of point of removal<br>**0:** to the left of WSP (**P-0-0135**, Bit0) |
| P-0-4084=0xFF81 | **0** | warning<br>(in 0xFF81) | **1:** active (**S-0-0135**, Bit12)<br>**0:** not active |
| | **1** | E-Stop-Status<br>(in 0xFF81) | **1:** active (**P-0-0223**, Bit0)<br>**0:** not active |
| P-0-4084=0xFF80<br>or<br>P-0-4084=0xFF81 | **2** | In reference | **1:** drive homed (**S-0-0403**, Bit0) |
| | **3** | In motion | **1:** In motion (**S-0-0013**, Bit1) |
| | **4** | In Position | **1:** drive within positioning window<br>& no following block (**S-0-0182**, Bit12) |
| | **5** | Error-Flag | **1:** no error (**S-0-0135**, Bit13)<br>**0:** error |
| | **6** | ready to operate Display bb | **1:** ready (**S-0-0135**, Bit14) |
| | **7** | power Display Ab | **1:** power is on (**S-0-0135**, Bit15) |
| P-0-4084=0xFF80 | **8 - 13** | travel block acknowledge | **P-0-4051, Process block acquittance**<br>(Bit 0 – Bit5) |
| | **14-15** | not assigned | |
| P-0-4084=0xFF81 | **8-15** | cam status | **P-0-0135**, **Status position switch**<br>(Bit 0 – Bit7) |

Fig. 6-4: Structure of P-0-4078, fieldbus status word in I/O mode in profile type P-0-4084=0xFF80 and 0xFF81

## How control and status bits work together (status machine)

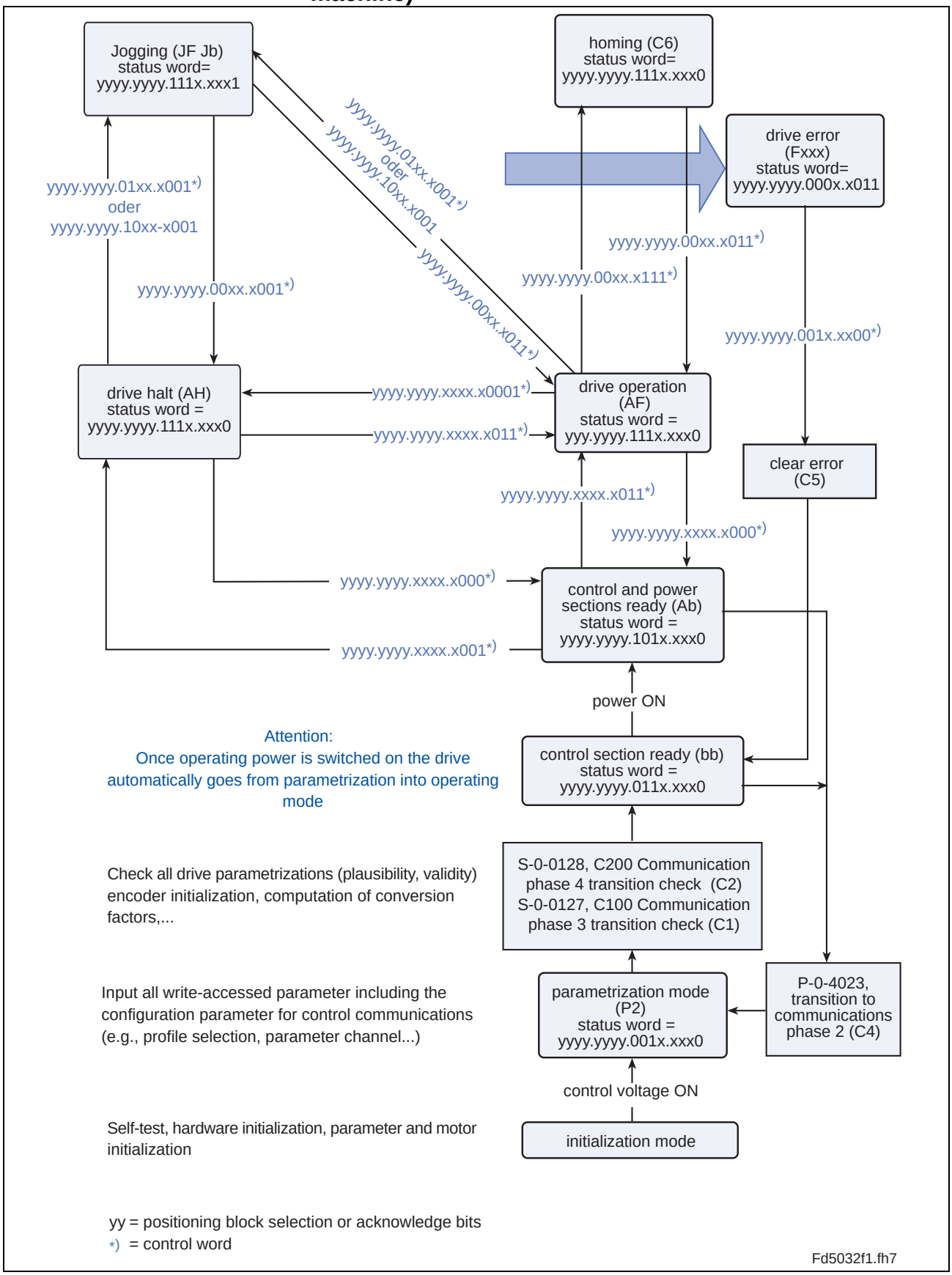



Fig. 6-5: Structure of status machine in I/O mode

**Note:** The data for the fieldbus status word refer to the I/O mode with block acknowledge (P-0-4084=0xFF80). In the other two types (0xFF81 and 0xFF82) only in bit 0, 1 and bit 8–15 have a different definition.

## I/O Mode-Default Setting

Features of the I/O mode default setting

- Fixed length of real-time channel of 2 bytes. This also fixes the length of the cyclic data channel (**P-0-4082** = **P-0-4087** = 2 + **P-0-4083**)!
- Bits 0 to 5 of **P-0-4051, Process block acquittance** are copied on to bits 8-13 of **P-0-4078, Fieldbus status word** (also see "Fig. 6-4: Structure of P-0-4078, fieldbus status word in I/O mode")
- In the real time channel only **P-0-4077, Fieldbus control word** and **P-0-4078, fieldbus status word** are transmitted.
- The structure of **P-0-4077, fieldbus control word** (also see "Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode") is identical to the structure in the I/O mode with cam status (**P-0-4084, Profile type** = 0xFF81)!

**Note:** With this profile selection, the functional compatibility to the drive controllers DKC3.1 is established! Controls that process the real time data in Motorola format have the high and low bytes swapped in comparison with the DKC3.1!

## I/O mode with cam ( P-0-4084= 0xFF81 )

Features of the I/O mode with cams

- Fixed length of real time channel of 2 bytes. The length of the cyclic data channel thus follows (**P-0-4082** = **P-0-4087** = 2 + **P-0-4083**)!
- Bits 0..7 of **P-0-0135, Status position switch** are copied to bits 8-15 of **P-0-4078, Fieldbus status word**
- Along with bits 8–15, bit 0 and bit 1 of **P-0-4078, Fieldbus status word** also have a different meaning from the backwards compatible profile type (**P-0-4084** = 0xFF80) (also see "Fig. 6-4: Structure of P-0-4078, fieldbus status word in I/O mode")!
- In the real time channel only **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word** are transmitted**.**
- The structure of **P-0-4077, Fieldbus control word** (also see "Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode") is identical to the structure in I/O mode with block acknowledgement (**P-0-4084, Profile type** = 0xFF80)!

## I/O mode freely expandable ( P-0-4084= 0xFF82)

Features of the freely expandable I/O mode

- The user can freely expand the length of cyclic data channel **P-0-4082** or **P-0-4087** up to a maximum of 9 words. In addition to the fieldbus control and status words, additional real time data can be configured via configuration lists **P-0-4080, Real-time input object structure** and **P-0-4081, Real-time output object structure**.
- The structure of **P-0-4077, Fieldbus control word** (also see "Fig. 6-3: Structure of P-0-4077, fieldbus control word in I/O mode") is identical to the structure in I/O mode with block acknowledgement (**P-0-4084** = 0xFF80).
- The contents of **P-0-4078, Fieldbus status word** is the same as that in **S-0-0144, Signal status word**, and can be freely parametrized via configuration lists **S-0-0026, Configuration list signal status word** and **S-0-0328, Assign list signal status word**.

# 6.3 Rexroth Indramat specific profile types

## Basic function of Rexroth Indramat Profile

To use the numerous and extensive functions of a Rexroth Indramat fieldbus drive it is necessary, in addition to the backwards compatible I/O mode of the DKC3.1 to define further profiles. This necessitates a new structure for **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word.**

A differentiation must in this case be made between:

- Fixed pre-defined profiles (**0xFF91**→drive-internal interpolation, **0xFF93**→velocity control and **0xFF92**→cyclic position control)
- and a completely free, configurable profile type (P-0-4084 = **0xFFFE**)

Each fieldbus drive of Rexroth Indramat, regardless of the command communications interface, is equipped with a uniform “status machine”. This includes a complete structure of the **P-0-4077, fieldbus control word** and **P-0-4078, fieldbus status word**. The interaction and the definition of the individual bits is described in the following section.

## "Rexroth Indramat status machine" of the drives

To explain how the individual bits work together, it is necessary to first explain the structure of the fieldbus control and status words.

**Note:** Parameters **S-0-0134, Master control word** and **S-0-0135, Drive status word** are only used for drive diagnostics. The actual control and status information is contained in **P-0-4077, Fieldbus control word** and **P-0-4078, Fieldbus status word**. These are always part of the real time channel.

## **Structure of P-0-4077, fieldbus control word** (Rexroth Indramat Profile)

| Bit | Name | Definition |
|---|---|---|
| **0** | Setpoint acceptance | a bit change indicates **(S-0-0346**, Bit0)<br>– a pos. block activated<br>– or position setting accepted |
| **1** | operating mode set | **0->1:** change to operating mode<br>**1->0:** change to parametrization mode |
| **2** | drive to zero point | **0->1:** reference command "C6" start (**S-0-0148** =11b)<br>**1->0:** reference command "C6" end (**S-0-0148** = 0b) |
| **3** | absolute / relative (only effective when used with **S-0-0282, Positioning command value**) | **0: S-0-0282, Positioning command value** is processed as abs. target pos. in drive<br>**1: S-0-0282, Positioning command value** is processed as rel. travel path in drive (S-0-0393, Bit3) |
| **4** | Immediate block change (only effective when used with **S-0-0282, Positioning command value**) | **0: S-0-0282, Positioning command value** not activated until target position is reached<br>**1: S-0-0282, Positioning command value** is immediately accepted after setpoint acceptance is toggled (S-0-0393, Bit4) |
| **5** | error delete | **0->1:** clear error command "C5" start<br>**1->0:** command "C5" end |
| **6** | jog forward | **1:** jog forward (**P-0-4056**, Bit0=1) |
| **7** | jog backwards | **1:** jog backwards (**P-0-4056**, Bit1=1) |
| **8, 9** | setpoint operating mode | **00:** main mode (**S-0-0134**, Bit 8,9)<br>**01:** 1st auxiliary mode (e.g., jog)<br>**10:** 2nd auxiliary mode<br>**11:** 3rd auxiliary mode |
| **10,11** | reserved | -- |
| **12** | IPOSYNC | Interpolator cycle (only in cycl. pos. control) toggles when new setpoint is transmitted |
| **13** | drive halt | **1->0:** Edge causes standstill of drive (**S-0-0134**, Bit 13) |
| **14** | drive enable | **1->0:** Edge causes immediate torque to zero (**S-0-0134**, Bit 14) |
| **15** | drive ON | **1->0:** Edge causes best possible standstill as per **P-0-0119** (**S-0-0134**, bit 15) |

Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles

## Structure of P-0-4078, fieldbus status word (Rexroth Indramat-Profiles)

**Note:** The definition of bit4 in **P-0-4077, Fieldbus control word** (setpoint reached) depends on profile type. With velocity control the information “Setpoint velocity reached” is displayed there. Whereby, in interpolation, the “In position” information is displayed.

**Status word for freely configurable modes**

| Bit | Name | Definition |
|---|---|---|
| **0,1** | operating mode-acknowledge | **10:** Phase4 (operating mode)<br>**01:** Phase3<br>**00:** Phase 2 (parametrization mode) |
| **2** | In-reference | **1:** drive homed (**S-0-0403**, Bit0) |
| **3** | In standstill | **1:** drive stands (**S-0-0013**, Bit1) |
| **4** | Setpoint reached | **1:** target position reached (**S-0-0182**, Bit10)<br>**Exceptions:**<br>-Profile type velocity control:<br>**1:** setpoint velocity reached (**S-0-0013**, Bit 0)<br>- Profile type cyclic position control<br>**1:** In position (**S-0-0013**, Bit 6) |
| **5** | command change bit | **1:** if command status has changed<br>**0:** if command status has not changed |
| **6** | operating mode-error | **1:** error in transition command<br>**0:** no error in transition command |
| **7** | Status setpoint processing | **1:** drive does not follow setpoint (e.g., if drive halt active)<br>**0:** drive follows setpoint |
| **8, 9** | actual operating mode | **00:** main mode<br>**01:** 1st aux. mode (e.g., jog)<br>**10:** 2nd aux. mode<br>**11:** 3rd aux. mode (**S-0-0135**, Bit 8,9) |
| **10** | Setpoint acknowledge | the drive acknowledges by toggling the bit (S-0-0419, Bit0) the acceptance of **S-0-0282, Positioning command value** |
| **11** | Message ZKL3 | the bit is set when a status class 3 message is present |
| **12** | warning ZKL2 | the bit is set when a status class 2 warning is present |
| **13** | drive error ZKL1 | the bit is set when a status class 1 error is pending (drive locked) **S-0-0135**, Bit 13) |
| **14, 15** | ready to operate | **00:** not ready for power<br>**01:** ready for power<br>**10:** control and power sections ready and torque free<br>**11:** in operation, with torque (**S-0-0135**, bits 14,15) |

ZKL1: Status class 1
ZKL2: Status class 2
ZKL3: Status class 3

Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles

## Interaction of Control and Status Bits (status machine)

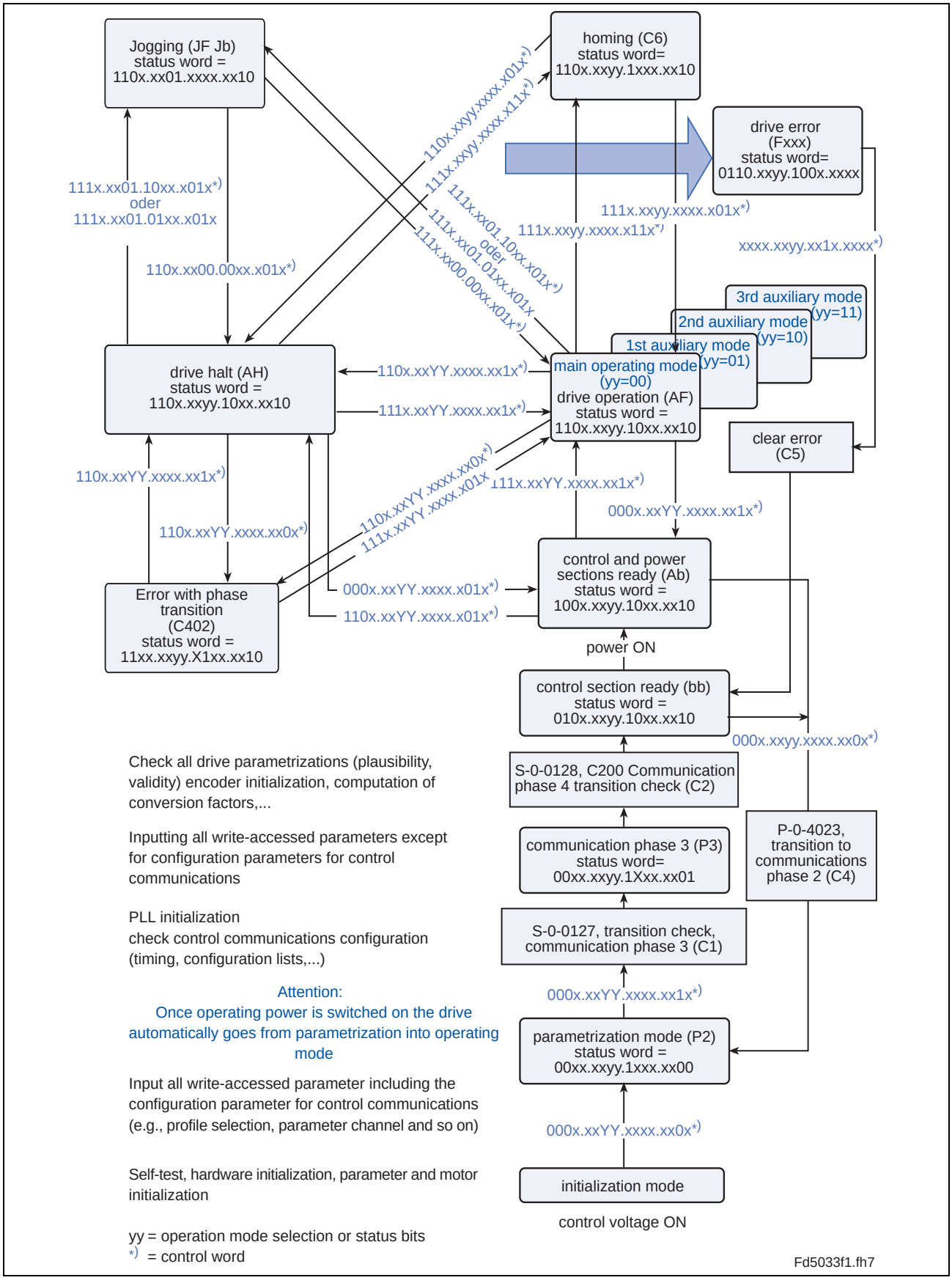



Fig. 6-8: Rexroth Indramat status machine (phase transition via fieldbus)

# Drive-internal interpolation ( P-0-4084= 0xFF91)

## Features

- The main operating mode “drive-internal interpolation lag-free with encoder 1" is set. Also see: "operating mode drive-internal interpolation". The first auxiliary mode is set to jog.
- The entire contents of the real time data channel is set with **P-0-4084, Profile type**. Via the fieldbus, parameters **S-0-0258, Target position** and **S-0-0259, Positioning Velocity** and **S-0-0051, Position feedback 1 value** and **S-0-0040, Velocity feedback value** are cyclical transmitted.
- In this profile type, the Rexroth Indramat specific definitions for fieldbus control and status words apply (also see section: Rexroth Indramat status machine" of the drives). Bits 0, 3, 4 and 12 in **P-0-4077**, **Fieldbus control word**, and bit10 in **P-0-4078, Fieldbus status word** are not relevant in this profile type.
- Length of cyclic data channel fixed with:
  **P-0-4082** = **P-0-4087** = 12 Byte [+ **P-0-4083]**
- The optional parameter channel can be expanded in Profibus-DP with **P-0-4083, Length of parameter channel in DP** to 6 words! (Default: **P-0-4083** = 0 → without parameter channel) !

**Note:** To use the functional expansion (transition absolute/relative) of the drive-internal interpolation, it is necessary to change into freely configurable mode (P-0-4084 = 0xFFFE). Then in the list P-0-4081 replace **S-0-0258, Target position** with **S-0-0282, Positioning command value**!

## Structure of the Real Time Data Channel

**Master → Slave** In the real time channel of the fieldbus, the travel block data configured in **P-0-4081, Real-time output object structure** are transmitted from the master to the drive.

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | i16 -> (1 word) |
| **S-0-0258, Target position** | i32 -> (2 words) |
| **S-0-0259, Positioning Velocity** | i32 -> (2 words) |
| **P-0-4076, Fieldbus container object** | i16 -> (1 word) |

**Slave → Master** In the real time channel of the fieldbus, the travel blocks configured in **P-0-4080, Real-time input object structure** are transmitted from the drive to the master:

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | i16 -> (1 word) |
| **S-0-0051, Position feedback 1 value** | i32 -> (2 words) |
| **S-0-0040, Velocity feedback value** | i32 -> (2 words) |
| **S-0-0390, Diagnostic message number** | u16-> (1 word) |

**Sequence in real time data channel:**

| | word1 | word2 | word3 | word4 | word5 | word6 |
|---|---|---|---|---|---|---|
| Master→ Slave | P-0-4077 | S-0-0258,H | S-0-0258,L | S-0-0259,H | S-0-0259,L | P-0-4076 |
| Slave →Master | P-0-4078 | S-0-0051,H | S-0-0051,L | S-0-0040,H | S-0-0040,L | S-0-0390 |

Fig. 6-9: Contents of real time channel in profile type interpolation

# Cyclic Position Control (P-0-4084= 0xFF92)

## Features

- In the main operating mode, “cyclic position control with encoder 1" is set. The 1st auxiliary mode is jog!
- The entire contents of the real time data channel is fixed with the setting in **P-0-4084, Profile type**. Parameters **S-0-0047, Position command value** and **S-0-0051, Position feedback 1 value** are cyclically transmitted via the fieldbus. The position setpoint processing in the drive is synchronised using a software PLL to the synchronization telegram (SYNC pulse) of the fieldbus.
- In this profile type, the Rexroth Indramat specific definitions of the fieldbus control and status word apply. Bits 0, 3 and 4 in **P-0-4077**, **Fieldbus control word** (also see "Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles"), as well as bit10 in **P-0-4078, Fieldbus status word** (also see "Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles") are not relevant in this profile type.
- **Bit 4** in **P-0-4078, Fieldbus status word** (setpoint reached) signals in this profile type that the drive is IN position (**S-0-0013**, Bit 6).
- Length of the cyclic data channel is fixed with:
  **P-0-4082** = **P-0-4087** = 8 bytes + **P-0-4083**

## Structure of the Real Time Data Channel

**Master → Slave** In the real time channel of the fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive.

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | i16 -> (1 word) |
| **S-0-0047, Position command value** | i32 -> (2 words) |
| **P-0-4076, Fieldbus container object** | i16 (1 word) |

**Slave → Master** In the real time channel of the fieldbus, the data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | i16 -> (1 word) |
| **S-0-0051, Position feedback 1 value** | i32 -> (2 words) |
| **S-0-0390, Diagnosis message number** | u16-> (1 word) |

**Real time data channel sequence:**

| | Word1 | Word2 | Word3 | Word4 |
|---|---|---|---|---|
| Master → Slave | **P-0-4077** | **S-0-0047**,H | **S-0-0047**,L | **P-0-4076** |
| Slave → Master | **P-0-4078** | **S-0-0051**,H | **S-0-0051**,L | **S-0-0390** |

Fig. 6-10: Contents of real time channel in cyclic position control

# Profile Type, Speed Control ( P-0-4084= 0xFF93)

## Features

- The main operating mode "Velocity control with filter and ramp" is set. (Also see: "Operating mode velocity control"). The 1st auxiliary mode is jog. (Also see section: "operating mode: jog")
- The contents of the real time data channel is fixed with **P-0-4084, Profile type**. Via the fieldbus, **S-0-0036, Velocity command value** and **S-0-0040, Velocity feedback value** are transmitted.
- In this profile type the Rexroth Indramat specific definitions for the fieldbus control and status words apply. Bits 0, 3, 4 and 12 in **P-0-4077**, **Fieldbus control word** (also see "Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles"), as well as Bit10 in **P-0-4078, Fieldbus status word** (also see "Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles") are not relevant in this profile type.
- **Bit 4** in **P-0-4078, Fieldbus status word** (setpoint reached) signals in this profile type that the setpoint speed has been reached(**S-0-0013**, Bit 0).
- the parameter channel can be set in Profibus-DP with **P-0-4083** to 6 words! (Default: **P-0-4083** = 0 → without parameter channel)!
- Length of cyclic data channel is fixed with:
  **P-0-4082** = **P-0-4087** = 12 Byte + **P-0-4083**

## Structure of Real Time Data Channel

**Master → Slave**

In the real time channel of the fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive:

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | i16 -> (1 word) |
| **S-0-0036, Velocity command value** | i32 -> (2 words) |
| **P-0-4076, Fieldbus container object** | i16 -> (1 word) |
| **P-0-4076, Fieldbus container object** | i16 -> (1 word) |
| **P-0-4076, Fieldbus container object** | i16 -> (1 word) |

**Note:** Filling-out with **P-0-4076, Fieldbus container object** is only necessary with Interbus-S (because of the bus structure), in order to keep the length of the real time channel constant.

**Slave → Master** In the real time channel of the fieldbus, the configured data in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | i16 -> (1 word) |
| **S-0-0040, Velocity feedback value** | i32 -> (2 words) |
| **S-0-0390, Diagnostic message number** | u16-> (1 word) |
| **S-0-0051, Position feedback 1 value** | i32 -> (2 words) |

**Sequence in real time data channel:**

| | word1 | word2 | word3 | word4 | word5 | word6 |
|---|---|---|---|---|---|---|
| Master → Slave | **P-0-4077** | **S-0-0036**,H | **S-0-0036**,L | **P-0-4076** | **P-0-4076** | **P-0-4076** |
| Slave → Master | **P-0-4078** | **S-0-0040**,H | **S-0-0040**,L | **S-0-0390** | **S-0-0051**,H | **S-0-0051**,L |

Fig. 6-11: Structure of real time channel in velocity control

# Freely configurable operating mode (P-0-4084=0xFFFE)

## Features

- The structure (content) of the real time data channel must be defined via the configuration lists in **P-0-4080** and **P-0-4081**. No profile-dependent settings and checks are carried out!
- In this profile type the Rexroth Indramat specific definitions for the fieldbus control and status words apply. Some bits (e.g., Bit 0, 3, 4 and 12 in **P-0-4077**, **Fieldbus control word** (also see "Fig. 6-6: Structure of P-0-4077, fieldbus control word in Rexroth Indramat profiles"), as well as Bit10 in **P-0-4078, Fieldbus status word** (also see "Fig. 6-7: Structure P-0-4078, fieldbus status word in Rexroth Indramat profiles") can, of course, only be used in conjunction with specific operating modes. This is clarified in the following examples.
- This profile type enables the use of the entire drive functionalities (e.g., velocity synchronization, multiplex channel and more).
- The main and auxiliary modes can be freely selected via **S-0-0032, S-0-0033, S-0-0034** and **S-0-0035**.

## Structure of real time data channel

**Note:** **P-0-4077, Fieldbus control word** as well as **P-0-4078, Fieldbus status word** must always assume 1st place in the configuration list **P-0-4080** and **P-0-4081**!

**Master → Slave** In the real time channel of the fieldbus the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive.

| Parameter | Format | Object |
|---|---|---|
| **P-0-4077, Fieldbus control word** | i16 -> (1 word) | 6040 |
| Optional setpoints | : | |

**Note:** The cyclic configurable setpoints are in the list parameter **S-0-0188, List of the configurable data in the MDT**.

**Slave → Master**

In the real time channel of the fieldbus, the data configured in **P-0-4080, Process data input description** are transmitted from drive to master:

| Parameter | Format | Object |
|---|---|---|
| **P-0-4078, fieldbus status word** | i16 -> (1 word) | 6041 |
| optional actual values | : | |

**Note:** The cyclic configurable actual values are in the list parameter **S-0-0187, List of configurable data in the AT**.

**Sequence in real time data channel:**

| | word1 | word2 | ... | word n |
|---|---|---|---|---|
| Master → Slave | **P-0-4077** | setpoint1 | ... | |
| Slave → Master | **P-0-4078** | actual value1 | ... | |

Fig. 6-12: Contents of real time channel in freely configurable mode

# 6.4 Example configurations for Rexroth Indramat profile

All the following examples relate to the freely configurable mode (**P-0-4084 = 0xFFFE**), as this is the most flexible mode in which to use the complete range of drive functions via the fieldbus.

## **Operating with analog setpoints** (Fieldbus master not active)

### Features

- It is possible to run the drive via analog velocity or torque setpoints.
- The control of the drive enable or drive halt does not run over the fieldbus, but rather over hardware inputs (X1 pin3, pin4) as long as the fieldbus communication is not active (e.g., removed bus connector). The status of the command communications is in parameter **P-0-4086, Command communication status**.

### Parametrization

To parametrize the analog mode

- set profile type to freely configurable mode (**P-0-4084** = 0xFFFE)
- set the main mode to velocity control with filter and ramp (**S-0-0032** = 10b)
  (Also see: "operating mode: velocity control")
- configure velocity setpoint at analog input 1 (**P-0-0213** = **S-0-0036**)
- the relevant evaluation of analog input must be set via **P-0-0214**
- all entries in configuration list **P-0-4080, P-0-4081**, must be cleared (**S-0-0036** may not be cyclically configured!).

# Using the Rexroth Indramat Positioning Setting

## Features

- In this operating mode a drive functionality is achieved which can be compared with the position target setting of DRIVECOM (function compatibility).
- By configuring **S-0-0282, Positioning command** as a cyclic setpoint bits 0, 3, 4 in **P-0-4077, Fieldbus control word** can be used to directly switch from relative to absolute positioning (function compatibility with position target setting).

## Parametrization

To parametrize the positioning setting

- set profile type to freely configurable mode (**P-0-4084** = 0xFFFE)
- set main operating mode to “positioning command” (**S-0-0032** = 10 0001 1011b) (Also see: "operating mode: drive-internal interpolation"

**Master → Slave**

In the real time channel of the fieldbus, the data configured in **P-0-4081, Real-time output object structure** are transmitted from master to drive.

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | I16 -> (1 word) |
| **S-0-0282, Positioning command** | I32 -> (2 words) |
| **S-0-0259, Positioning Velocity** | I32 -> (2 words) |
| **P-0-4076, Fieldbus container object** | I16 -> (1 word) |

**Slave → Master**

In the real time channel of the fieldbus, the data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | I16 -> (1 word) |
| **S-0-0051, Position feedback 1 value** | I32 -> (2 words) |
| **S-0-0040, Velocity feedback value** | I32 -> (2 words) |
| **S-0-0390, Diagnostic message number** | U16-> (1 word) |

**Sequence in real time data channel:**

| | word1 | word2 | word3 | word4 | word5 | word6 |
|---|---|---|---|---|---|---|
| Master→ Slave | **P-0-4077** | **S-0-0282**,H | **S-0-0282**,L | **S-0-0259**,H | **S-0-0259**,L | **P-0-4076** |
| Slave →Master | **P-0-4078** | **S-0-0051**,H | **S-0-0051**,L | **S-0-0040**,H | **S-0-0040**,L | **S-0-0390** |

Fig. 6-13: Contents of real time channel in Indramat positioning setting

# Using the multiplex channel in positioning block mode

By using the multiplex channel, the number of cyclically transmitted data bytes can be increased. This means that the use of this option always makes sense if the real time channel does not suffice for the pending task.

Also see section: "Multiplex channel".

## Features

- By using the multiplex channel, the number of cyclically transmitted real time data can be increased.
- Since **S-0-0362, List index, MDT data container A** is also configured, single elements in list parameters (**P-0-4006**, **P-0-4007** and **P-0-4009**) can also be changed via the real time channel (multiplex channel).
- By evaluating **S-0-0368, Addressing for data container A** and **S-0-0362, List index, MDT data container A** in the master, a check (handshake) for the multiplex channel can be implemented.

**Note:** The multiplexed real time data are processed in the drive as is the rest of the real time data, i.e., the values are not buffered!

## Parametrization

To use the multiplex channel, the following parametrization is necessary:

- set profile type to freely configurable mode (**P-0-4084** = 0xFFFE)
- set parameter **S-0-0032, Primary mode of operation** e.g., to "positioning block mode, lag free with encoder 1"
- The configuration lists of the multiplex channel **S-0-0370, S-0-0371** can be parametrized as follows:

**S-0-0370, Configuration list MDT data container**

| Contents of S-0-0370 | Index |
|---|---|
| **P-0-4006, Process block target position** | 0 |
| **P-0-4007, Process block velocity** | 1 |
| **P-0-4008, Process block acceleration** | 2 |

**S-0-0371, Configuration list AT data container**

| Contents of S-0-0371 | Index |
|---|---|
| **P-0-4006, Process block target position** | 0 |
| **P-0-4007, Process block velocity** | 1 |
| **P-0-4008, Process block acceleration** | 2 |
| **S-0-0040, Velocity feedback value** | 3 |

The configuration lists P-0-4080, P-0-4081 can be parametrized as follows:

**Master → Slave**

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | I16 -> (1 word) |
| **P-0-4026, Process block selection** | I16 -> (1 word) |
| **S-0-0368, Addressing for data container A** | I16 -> (1 word) |
| **S-0-0362, List index, MDT data container A** | I16 -> (1 word) |
| **S-0-0360, MDT Data container A** | I32 -> (2 words) |

**Slave → Master**

In the real time channel of the fieldbus, the data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | I16 -> (1 word) |
| **P-0-4051, Process block acquittance** | I16 -> (1 word) |
| **S-0-0051, Position feedback 1 value** | I32 -> (2 words) |
| **S-0-0364, AT Data container A** | I32 -> (2 words) |
| **S-0-0368, Addressing for data container A** | I16 -> (1 word) |
| **S-0-0362, List index, MDT data container A** | I16 -> (1 word) |

**Sequence in real time data channel:**

| | word1 | word2 | word3 | word4 | word5 | word6 | word7 | word8 | word9 |
|---|---|---|---|---|---|---|---|---|---|
| Master→ Slave | P-0-4077 | P-0-4026 | S-0-0368 | S-0-0362 | S-0-0360,L | S-0-0360,H | | | |
| Slave → Master | P-0-4078 | P-0-4051 | S-0-0051,H | S-0-0051,L | S-0-0368,L | S-0-0362,L | S-0-0364,L | S-0-0364,H | |

Fig. 6-14: Contents of real time channel in positioning block mode with multiplex channel

# Using the signal control and status words

By using **S-0-0145, Signal control word** and **S-0-0144, Signal status word** the user has the option to configure control and status bits in the drive himself, which are also transmitted along with the fieldbus control and fieldbus status word in real time via the fieldbus.

Also see section "Configurable signal control word" and "Configurable signal status word".

## Features

- By using **S-0-0144** and **S-0-0145** 16 more freely configurable control and status bits become available.
- Makes possible the start of commands which are entered in list **S-0-0399, IDN list of configurable data in the signal control word** via a bit in the signal control word (compare with signal control word).
- Makes possible the reading of any bit in any parameter (compare with signal status word).

## Parametrization

The following settings are needed:

- To configure the bit strips, use the configuration lists **S-0-0026**, **S-0-0328** (for **S-0-0144**) and **S-0-0027**, **S-0-0329** (for **S-0-0145**).
- To use the function, select profile type “freely configurable mode" (**P-0-4084** = 0xFFFE).
- Parameter **S-0-0032, Primary mode of operation** e.g., can be set to "drive-internal positioning setting, lag error free with encoder 1".
- The configuration lists **P-0-4080** and **P-0-4081** must be parametrized as follows:

**Master → Slave**

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | I16 -> (1 word) |
| **S-0-0282, Positioning command** | I32 -> (2 words) |
| **S-0-0259, Positioning Velocity** | I32 -> (2 words) |
| **S-0-0145, Signal control word** | I16 -> (1 word) |

**Slave → Master**

In the real time channel of the fieldbus, the travel block data configured in **P-0-4080, Real-time input object structure** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | I16 -> (1 word) |
| **S-0-0051, Position feedback 1 value** | I32 -> (2 words) |
| **S-0-0040, Velocity feedback value** | I32 -> (2 words) |
| **S-0-0390, Diagnostic message number** | I16-> (1 word) |
| **S-0-0144, Signal status word** | I16 -> (1 word) |

**Sequence in real time data channel:**

| | word1 | word2 | word3 | word4 | word5 | word6 | word7 |
|---|---|---|---|---|---|---|---|
| Master→ Slave | P-0-4077 | S-0-0282,H | S-0-0282,L | S-0-0259,H | S-0-0259,L | S-0-0145 | P-0-4076 |
| Slave → Master | P-0-4078 | S-0-0051,H | S-0-0051,L | S-0-0040,H | S-0-0040,L | S-0-0390 | S-0-0144 |

Fig. 6-15: Contents of real time channel in interpolation with signal control and status words

# Cam mode with real master axis

## Features

- In this operating mode the drive itself generates the position setpoints out of a per cent value table dependent on the position of the master axis encoder. These table values are multiplied by the so-called hub and then become the synchronous position setpoint. The drive controls the actual position value based on this synchronous position setpoint.
- By emulating the actual position value of a master drive axis, a master axis coupling between a “Master drive" and a slave drive can be realized.

## Parametrization

To parametrize the cam function with real master axis

- set **P-0-4084, Profile type** =0xFFFE (freely configurable mode)
- parameter **S-0-0032, Primary mode of operation** must be set to “cam, lag error free with encoder 1"
- for an optional encoder, select for example., **P-0-0075** = 5, for relative master axis encoder
- use **S-0-0145, Signal control word** and **S-0-0144, Signal status word**, to transmit the mode-specific control and status bits in a cyclical manner
- parametrize configuration lists **P-0-4080, P-0-4081** as follows (suggested values):

**Master → Slave**

In the real time channel of the fieldbus, the data configured in **P-0-4081, Process data output descriptions** are transmitted from master to drive.

| Parameter | Format |
|---|---|
| **P-0-4077, Fieldbus control word** | I16 -> (1 word) |
| **S-0-0145, Signal control word** | I16 -> (1 word) |
| **S-0-0048, Position command value additional** | I32 -> (2 words) |
| **P-0-0156, Master drive gear input revolutions** | I16 -> (1 words) |
| **P-0-0157, Master drive gear output revolutions** | I16 -> (1 words) |
| **P-0-0093, Cam shaft distance** | I32 -> (2 words) |

**Slave → Master**

In the real time channel of the fieldbus, the real time data configured in **P-0-4080, Process data input description** are transmitted from drive to master.

| Parameter | Format |
|---|---|
| **P-0-4078, Fieldbus status word** | I16 -> (1 word) |
| **S-0-0144, Signal status word** | I16 -> (1 word) |
| **S-0-0051, Position feedback 1 value** | I32 -> (2 words) |
| **S-0-0040, Velocity feedback value** | I32 -> (2 words) |
| **S-0-0390, Diagnostic message number** | I16-> (1 word) |

**Sequence in real time data channel:**

| | word1 | word2 | word3 | word4 | word5 | word6 | word7 | word8 |
|---|---|---|---|---|---|---|---|---|
| Master→ Slave | P-0-4077 | S-0-0145 | P-0-0156 | P-0-0157 | S-0-0048,H | S-0-0048,H | P-0-01 | P-0-4076 |
| Slave → Master | P-0-4078 | S-0-0144 | S-0-0051,H | S-0-0051,L | S-0-0040 | S-0-0040 | S-0-0390 | |

Fig. 6-16: Contents of the real time channel in the cam with real master axis

# 6.5 Multiplex Channel

## Overview

The multiplex channel makes it possible to update a limited cyclical data channel. This also enables cyclical list element accessing with index changes.

**Note:** To be able to use the mechanism it is necessary to use command communications via SERCOS or Profibus and configure the multiplex parameter in the cyclical telegrams. The use of the multiplex channel is only possible with a "freely-configurable operating mode" (P-0-4084 = 0XFFFE).

With the help of the multiplex channel it is possible:

- to cyclically exchange more parameter contents despite limited maximum number of transmittable bytes in the master data telegram and drive telegram.
- to access individual list elements using both indices S-0-0362 and S-0-0366.
- by incrementing index S-0-0368 to transmit in each cycle the multiplexed data with a cycle time of *Tscyc * number of multiplex data.*
- to structure the index in terms of the operating mode and thus to transmit only those parameters needed for the activated mode.

## Pertinent Parameters

The following parameters are used:

- **S-0-0360, MDT Data container A**
- **S-0-0362, List index, MDT data container A**
- **S-0-0364, AT Data container A**
- **S-0-0366, List index, AT data container A**
- **S-0-0368, Addressing for data container A**
- **S-0-0370, Configuration list for the MDT data container**
- **S-0-0371, Configuration list for the AT data container**

## Functional Principle Multiplex Channel

### Configuration

**S-0-0370, Configuration list for the MDT data container**

The IDNs are entered in parameter **S-0-0370, Configuration list for the MDT data container** which are dependent on the index in **S-0-0368, Addressing for data container A,** low byte, and transmitted to **S-0-0360, MDT Data container A**. Write accessing S-0-0370 is only possible in communications phase 2.

**S-0-0371, Configuration list for the AT data container**

The IDNs are entered in parameter **S-0-0371, Configuration list for the AT data container A** that are dependent on indices in **S-0-0368, Addressing for data container A**, (high byte), and transmitted to **S-0-0364, AT Data container A**. Write accessing S-0-0371 is only possible in communications phase 2.

**Note:** A maximum of 32 IDNs can be configured in S-0-0371.

## Addressing the Data Container

**S-0-0368, Addressing data container A**

Parameter **S-0-0368, Addressing for data container A** contains indices for the selection of the parameters transmitted in the data container.

The graph below illustrates the configuration lists with the maximum number of elements (32).

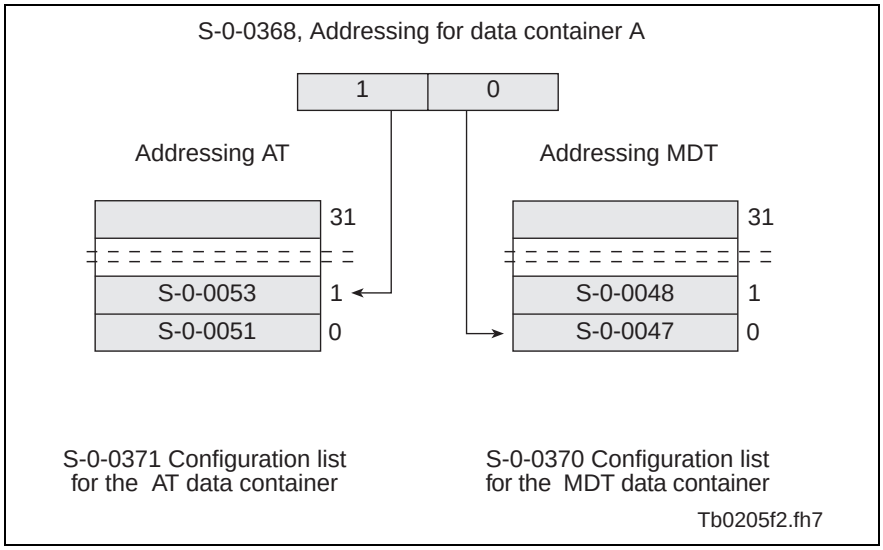



Fig. 6-1: Functional principle of addressing data container A

**Note:** Only bits 0..5 (for MDT) and bits 8..13 (for AT) are used for addressing with parameter S-0-0368. The other bits are cut off.
This is why no value exceeding 31 can be used for addressing.

**Note:** Parameter **S-0-0368, Addressing for data container A** can, depending on requirements, be configured in MDT, write accessed via the required data channel or some other interface.

## Using the Data Container

**S-0-0360, MDT Data container A**

In parameter **S-0-0360, MDT Data container A** the master transmits the data which will be written to the target parameter in the drive.

The target parameter is that parameter addressed via S-0-0368 in the configuration list (S-0-0370).

**Note:** Parameter S-0-0360 is **not write accessible via the required data channel.** The display format is hexadecimal without decimal places.

**S-0-0364, AT Data Container A**

**The drive copies the data of the source parameter into parameter S-0-0364, AT Data container A**.

The source parameter is that parameter addressed via S-0-0368 in the configuration list (S-0-0370).

**Note:** Parameter S-0-0364 is **not write accessible via the required data channel.** The display format is hexadecimal without decimal places.

## Processing Single List Elements

Using both addressing parameters

- **S-0-0362, List index, MDT data container A**
- **S-0-0366, List index, AT data container A**

it is possible to access single elements of list parameters. It is thus possible to cyclically and by element write into list parameters. The element to be written into or read of a list parameter is written into both parameters.

**Note:** The parameters become effective if in **S-0-0368, Addressing for data container A** a list parameter has been addressed. If the addressed parameter is not a list parameter, then the evaluation of parameters S-0-0362 and S-0-0366 is terminated.

The following illustrates the processing of a list element with the use of the multiplex channel.

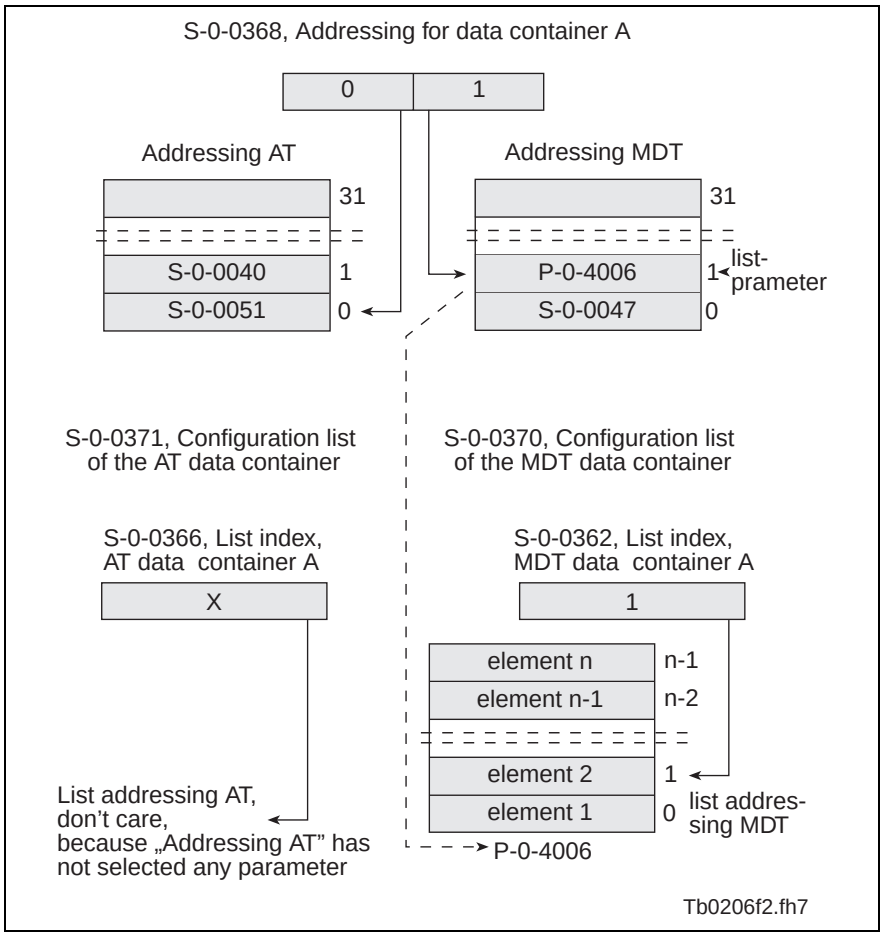



Fig. 6-2: Processing list elements with the multiplex channel, here for the MDT container

# Diagnostic Messages

In conjunction with the multiplex channel, various checks are conducted:

## Checking the Configured IDN Order

**Checks in transition command**

The temporal sequence of the processing of cyclical MDT data in the drive has an order specified with which the configured IDNs are entered in parameter **S-0-0024, Config. list of the master data telegram**.

If both the parameter **S-0-0360, MDT Data container A** and **S-0-0368, Addressing for data container A** are configured in the MDT, then the MDT data container will only be properly processed if the addressing was previously processed.

To maintain the correct order when configuring the MDT, the drive checks in command **S-0-0127, C100 Communication phase 3 transition check** whether the IDN S-0-0368 is configured before S-0-0360. If not, then the drive generates a command error message.

- **C118, MDT order for configuration faulty**

## Checking the Configuration Lists

It must be ensured that the ID numbers in the configuration lists can be cyclically configured.

This is why it is checked in command **S-0-0127, C100 Communication phase 3 transition check**, whether ID numbers in **S-0-0187, List of configurable data in the AT** or **S-0-0188, List of configurable data in the MDT** are contained in the list.

The following errors are possible:

If list **S-0-0370, Configuration list for the MDT data container** has one or more IDNs which are not available are not in **S-0-0188 ,List of configurable data in the MDT** then error message

- **C104 Configured ID number for MDT not configurable**

is generated.

If list **S-0-0371, Configuration list for the AT data container** contains one ore more IDNs that are not available or not in **S-0-0187, List of configurable data in the AT** then error message:

- **C106 Configurated ID numbers for AT not configurable**

is generated.

## Checking for Existing ID Numbers

**Checking the input**

When inputting S-0-0370 and S-0-0371 the following checks are conducted:

- It is checked whether the entered IDN is available. If not, then the data channel error message "0x1001, ID number not available" is generated.
- It is checked whether the entered IDN in parameter **S-0-0188, List of configurable data in the MDT** is available. If not, then the data channel error message "0x7008, Data not correct" is generated.

## Checking the Indices

**Checking while running**

The drive monitors whether the index shows non-initialized locations in lists S-0-0370, **Configuration list for the MDT data container or** S-0-0371, **Configuration list for the AT data container.**

If it does, then warnings:

- **E408 Invalid addressing of MDT data container A**
- **E409 Invalid addressing of AT data container A**

is generated.

---

**Note:** The warnings can only occur if the lists has fewer ID number entries than is maximally possible.

---

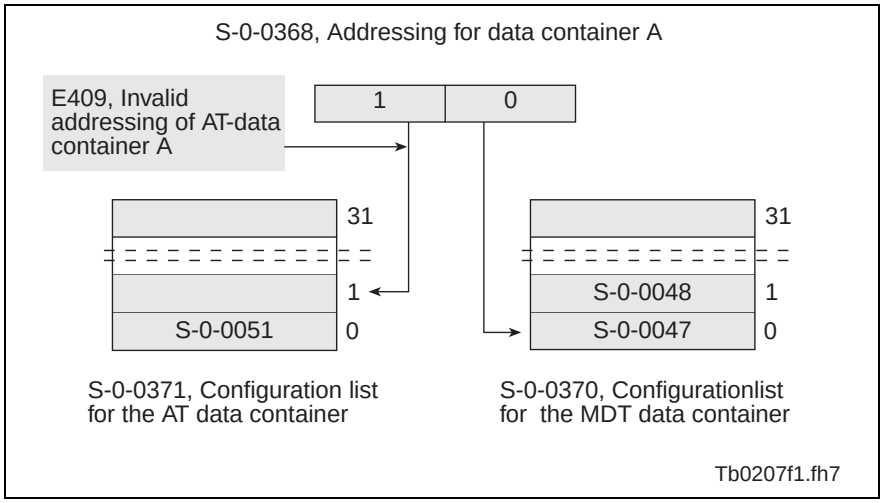



Fig. 6-3: Invalid addressing of MDT data container A

## Notes

# 7 Motor Configuration

## 7.1 Characteristics of the Different Motor Types

You can use the following motor types.

| | |
|---|---|
| MKD | MHD |
| 2AD | ADF |
| 1MB | MBW |
| MKE | LAR |
| MBS | LSF |
| | LAF |

The individual motor types differ in the following points:

- Availability of data memory in the motor feedback for all motorspecific parameters
- Synchronous motor - Asynchronous motor
- Linear motor - rotational motor
- Temperature check can be changed or not.
- Basic load (load default) is possible when a Feedback-Data Memory is present.
- Motor encoder interface setting can be changed or one setting only
- Start of commutation offset setting command possible or not
- Motor temperature sensor with PTC or NTC features

The individual motor types have the following characteristics

| Motor type | Motor feedback data memory | Sync./Async. | Temp. check | Motor-encoder interface | Load default | Temp. Sensor |
|---|---|---|---|---|---|---|
| MHD/MKD/MKE | yes | synchronous | fixed | fixed (1) | possible | PTC |
| 2AD/ADF | no | asynchronous | param. | param. | no | NTC |
| 1MB | no | asynchronous | param. | param. | no | NTC |
| LAF/LAR | no | asynchronous | param. | param. | no | PTC |
| LSF | no | synchronous | param. | param. | no | PTC |
| 2AD with PTC | no | asynchronous | param. | param. | no | PTC |
| MBS | no | synchronous | param. | param. | no | PTC |

Fig. 7-1: Characteristics of the Motor Types part 1

see also parameter description: **P-0-4014, Motor type**

## Motor Feedback-Data Memory

**The motor feedback data memory contains all motor-related parameters**

For MHD, MKD and MKE motors, a motor feedback-data memory is provided, in which all motor-dependent parameters are stored. The drive controller recognizes this automatically and reads those parameters after turning on the device from the data memory with the command **S-0-0128, C200 Communication phase 4 transition check**.

The data memory contains values for the following parameters:

- **S-0-0109, Motor peak current**
- **S-0-0111, Motor current at standstill**
- **S-0-0113, Maximum motor speed (nmax)**
- **S-0-0141, Motor type**
- **P-0-0018, Number of Pole Pairs/Pole Pair**
- **P-0-0051, Torque/Force constant**
- **P-0-0510, Moment of inertia of the rotor**
- **P-0-0511, Brake current**

**Note:** Motor types without motor feedback memory necessitate that these parameters are input at the initial start-up using the data sheet.

## Linear-Rotational

**Units are motordependent**

Depending on whether a linear or rotary motor is being used, changes in the units and the number of decimal places of the parameters will be made. The following table displays the differences in scaling of these parameters:

| ID number: | Rotational: | Linear: |
|---|---|---|
| S-0-0100 | 0,1 As/rad | 0,1As/m |
| S-0-0113 | 0,0001 RPM | 0,0001 mm/min |
| S-0-0116 | Cycles/Rev. | 0.00001 mm |
| P-0-0018 | Pole pairs | 0,1mm |
| P-0-0051 | Nm/A | N/A |
| S-0-0348 | mAs²/rad | mAs²/mm |

Fig. 7-2: Scaling in Linear or Rotary Motors

The selected motor type also affects the scaling of the position data.

For example, it is impossible to set rotary motor settings for linear motors and linear motor settings for rotary motors. This would generate the command error **C213 Position data scaling error** during a phase progression.

## Synchronous-Asynchronous

Specific parameters are used only for synchronous motors, others only for asynchronous motors.

There are differences in the use and review of the parameters in the command **S-0-0128, C200 Communication phase 4 transition check**.

They are:

**Synchronous:**

- **P-0-4004, Magnetizing current** is set to 0 if need be
- **P-0-0508, Commutation offset** is checked for validity
- **P-0-4047, Motor inductance** is initialized.

**Asynchronous:**

- **P-0-4004, Magnetizing current** is initialized
- **P-0-0508, Commutation offset** is not checked

## Temperature Monitoring

*The switch-off limit for the motor temperature check is fixed at one point for MHD-, MKD, MKE motors.*

The following parameters are used to monitor the motor temperature :

**S-0-0201, Motor warning temperature**

**S-0-0204, Motor shutdown temperature**

For MHD, MKD and MKE motors, the parameter default values are:

**S-0-0201, Motor warning temperature** = 145,0°C

**S-0-0204, Motor shutdown temperature** = 155,0°C

Those default values can be used to help set the parameters for all other motor types. However, you must ensure that the switch-off limit is not set higher than the maximum permissible temperature of the motor.

The maximum input value for **S-0-0201, Motor warning temperature** is **S-0-0204, Motor shutdown temperature**.

If the temperature of the motor exceeds the value in **S-0-0201, Motor warning temperature**, the warning message **E251 Motor overtemp. prewarning** is generated.

If the temperature rises to the motor switch-off temperature, the error message **F219 Motor overtemp. shutdown** is displayed.

The minimum input value for **S-0-0204, Motor shutdown temperature** is **S-0-0201, Motor warning temperature**.

---

**Note:** To display the motor temperature, the parameter **S-0-0383, Motor Temperature is used.**

---

The drive controller checks for proper functioning of the motor temperature monitoring system. If discrepancies occur (temperature drops below –10° celsius), the warning **E221 Warning Motor temp. surveillance defective** will be displayed for 30 seconds. After that, the error message **F221 Error Motor temp. surveillance defective** is generated.

## Load Default Feature

MHD, MKD and MKE motors have a data memory in their feedbacks. The data memory contains a set of default control parameters in addition to all motor-dependent parameters.

These parameters are activated with the load default feature.

(See also "Load Default Feature")

# 7.2 Setting the Motor Type

The setting of the motor type is done either:

- it depends on the used motor type.
- automatically by reading the motor feedback memory or
- through the input of the parameter **P-0-4014, Motor type.**

The motor type should be set before start up because the motor type affects the drive functions:

See also Chapter: "Characteristics of the Different Motor Types"

## Automatic Setting of the Motor Type for Motors with Feedback Memory

MHD, MKD and MKE motors have a motor feedback data memory, in which the motor type is stored (along with other information). The drive controller recognizes these motor types automatically and the following is executed:

- the value of the parameter **P-0-4014, Motor type** is set to its proper value and will be write-protected.
- the value of the parameter **P-0-0074, Feedback 1 type** is set to the defined value for the corresponding motor type.
- all bits except bit 6 (for absolute/not-absolute) are set to "0" in the parameter **S-0-0277, Position feedback 1 type**.
- all motor-dependent parameters are read out of the motor feedback data storage (see "Motor Feedback-Data Memory"). The parameter in the motor feedback memory are set with parameter block number 7. These are retrieved and copied into the relevant parameters with parameter block number 0.
- the value of **S-0-0201, Motor warning temperature** will be set to 145,0°C, and the **S-0-0204, Motor shutdown temperature** will be set to 155,0°C.
- The value of **P-0-0525, Type of motor brake** is set to "0". The value of **P-0-0526, Brake control delay** is set to 150 ms.

This procedure is followed right after switching on as in the command **S-0-0128, C200 Communication phase 4 transition check**. The command error message, **C204 Motor type P-0-4014 incorrect**, will be generated in case an MHD, MKD and MKE motor is selected in **P-0-4014, Motor type** but the corresponding character sequence cannot be found in the motor feedback data memory.

## Setting of the Motor Type through P-0-4014, Motor Type

For motors without motor feedback data memory, you have to set the motor type through **P-0-4014, Motor type**.

See also: "Characteristics of the Different Motor Types"

# 7.3 Asynchronous Motors

With the Firmware, you can use asynchronous motors in the entire rpm range, including constant power range.

In addition to the general motor parameters, you have to set the following asynchronous motor parameters for specific motors according to the Indramat default:

- **P-0-4004, Magnetizing current**
- **P-0-4012, Slip factor**
- **P-0-0530, Slip Increase**
- **P-0-0531, Stall Current Limit**
- **P-0-0533, Flux Loop Prop. Gain**
- **P-0-0534, Flux Loop Integral Action Time**
- **P-0-0535, Motor voltage at no load**
- **P-0-0536, Motor voltage max.**

The user has one additional parameters to adjust the drive to his requirements.

- **P-0-0532, Premagnetization factor**

## Basics for the Asynchronous Motor

Asynchronous motors are divided in three working ranges.

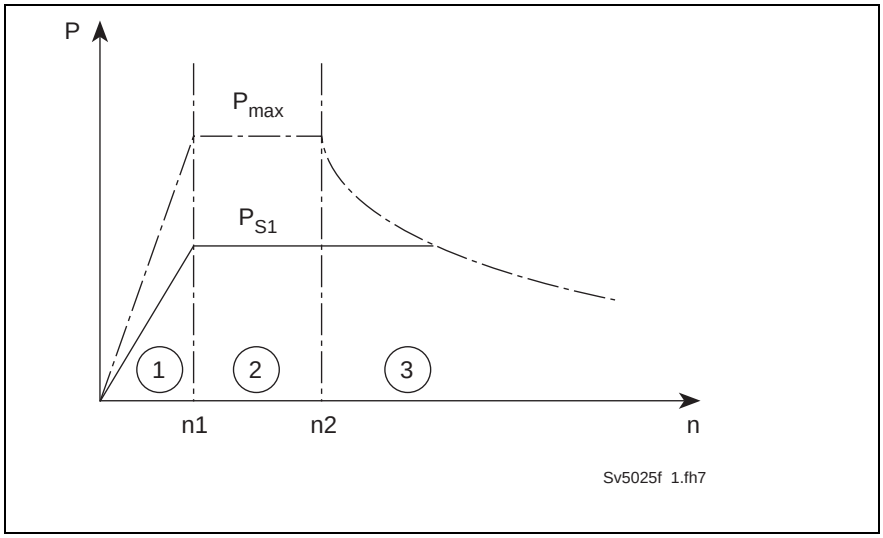



Fig. 7-3: Subsections of Work Ranges

**Range 1:**

The Basic RPM Range is defined by a constant torque and a fixed torque/force constant (parameter P-0-0051). In idle, the programmed magnetization current flows. The motor voltage is less than the maximum control output voltage. The corner RPM n1 is directly proportional to the DC bus voltage.

**Range 2:**

**Range of Constant Power**. The motor voltage is constant; the idle voltage and the corresponding magnetization and torque constants fall with increasing velocity. The slip is increased correspondingly.

The adjustment of magnetization current and slip is executed automatically by the vector control. The voltage is decreased during idle to the motor idle voltage (P-0-0535), and when fully in use it is increased to the maximum motor voltage (P-0-0536).

**Range 3:**

**Range of decreasing Peak Power**. The motor works at the stability limit; through the vector control, the current is maintained at an efficient and stable level. According to the parameter "current stability limit," the peak current will be decreased enough so that the maximum power cannot be exceeded. An increase in current would lead only to wasted power and reduced output power. The peak power in range 3 is proportional to the square of the DC bus voltage. It is ensured that the maximum power always is reached for each DC bus voltage without parameter adjustment.

The power in range 3 cannot be extended through the use of more powerful controllers.

## Torque Evaluation

100% torque refers to the motor's nominal torque according to the ID plate. Since the peak torque of asynchronous motors is limited to 2.5 times of the nominal value, you can reach torques up to 250%.

The significance of the torque values changes in the field-weakening range since the torque in the controller is set equal to the torque-producing current Iq. The torque, however, is the product of Iq and air gap induction, which decreases in the field-weakening range.

The assignment of the torque values in the different velocity ranges is displayed in the following picture:

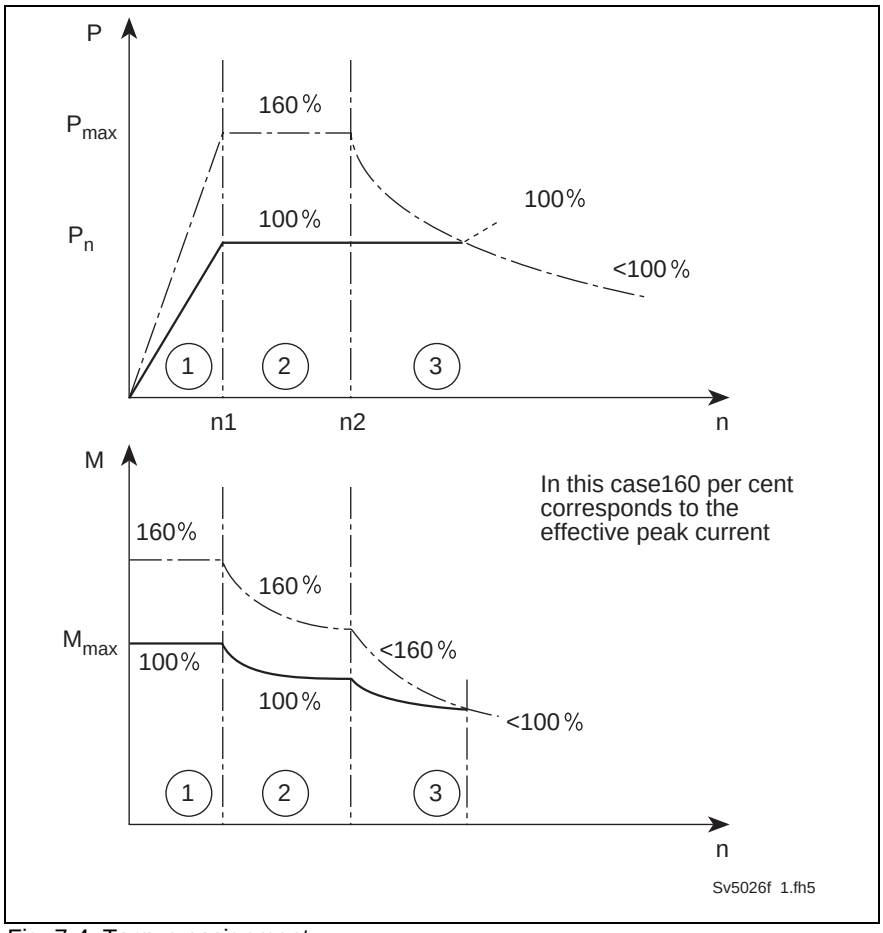



Fig. 7-4: Torque assignment

**In range 1**, the torque value is the actual torque. 100% = rated torque.

**In range 2**, the torque value corresponds to the power.
100% = rated power according to selection list. (The rated power of the motor rating plate is not relevant here since it could relate to another DC bus voltage.)

**Range 3** is similar to the evaluation of range 2, except that the preset torque decreases in correspondence to the increasing velocity of the peak power. For high velocity, the maximum torque value can drop below 100%.

In braking mode, you can reach 50% higher torque values in this range than in driving mode.

## User-defined Settings for the Asynchronous Motor

To operate an asynchronous motor, you have to set the specific motor parameters in the controller. The Parameters are stored in the Parameterstorage and are therefore transferable to another controller.

**Note:** Motor-specific parameters are used by all controls in the same manner. The resulting power characteristics curve depends on the current and especially on the DC bus voltage. Several additional parameters are available so the user can optimize the drive to his requirements.

## Scaling Factor Pre-Magnetizing

With **P-0-0532, Premagnetization factor** you can set the active magnetization current.

The following applies:

Effective magnetization current = magnetization voltage • scaling factor pre-magnetizing

Fig. 7-5: Calculation of the Effective Magnetization Current

If the pre-magnetizing scaling factor is at 100%, the motor is completely magnetized. There is a linear connection between set current and torque according to the torque constant P-0-0051. The torque builds up without delay. The drive has perfect servo properties.

The disadvantages are the high iron loss and the higher noise under no or partial load, especially at 4 kHz switching frequency, when the full magnetization current is flowing. For main spindle applications, it has proven successful to reduce the pre-magnetizing scaling factor to 50%. Through this procedure, the motor stays cooler and is not as noisy, while peak power is maintained. The extended start control time (only for jumps that exceed half the peak torque) and the missing linearity of torque and voltage do not distort the main spindle drives.

With a 50% pre-magnetizing factor the qualitative connection between the pre-magnetizing scaling factor (pmf) and drive behavior is displayed in the following graphic:

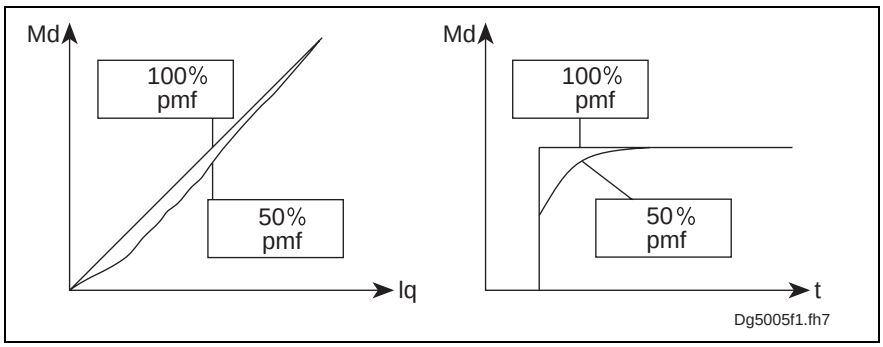



Fig. 7-6: Connection of pre-magnetizing scaling factor and drive behavior

The torque buildup is delayed by about 200 ms during pre-magnetizing because the air gap range can only increase slowly in relation to the rotor time constant.

By reducing the pre-magnetizing scaling factor, you can achieve a better synchronous operation (in the one-thousandth degree range). This will reduce distorted torques, which result from saturation effects in the motor and from unavoidable deviations from an ideal sine form. To keep the torque linear in this case, the slip factor must be increased in the same measure at which the pre-magnetizing scaling factor was decreased. Warning: Torque constant, continual torque and peak torque are reduced!

Example: The synchronous operation should be improved in a servo drive. The pre-magnetizing scaling factor is set to 40%, and the slip factor is set to 2.5 times of the original value. The continuous and peak torque decrease to approximately 40%. The base speed increases to 2.5 times the rated base speed.

# 7.4 Synchronous Motors

With this drive firmware it is possible to run Rexroth Indramat housing motors

- MHD
- MKD and MKE motors

plus rotary and linear synchronous kit motors MBS and LSF. Indramat housing motors have stator, rotor, bearings and feedback built into the housing. They are equipped with a motor feedback data memory in which

- motor parameters
- motor feedback parameters
- synchronous motor-specific parameters and
- default control parameters

**Automatic detection and parameterization of Rexroth Indramat housing motors (MHD and MKD motors)**

are stored. These motors are recognized by the firmware and the correct setting for them is automatic. The compensation between the physical rotor position and the position supplied by the feedback is set at the factory in these motors. The offset results are stored in parameter **P-7-0508, Commutation offset** in the motor feedback memory (synchronous motor parameter). Rexroth Indramat housing motors are configured ready for operation at the factory meaning that they can be run without having to make any motor settings.

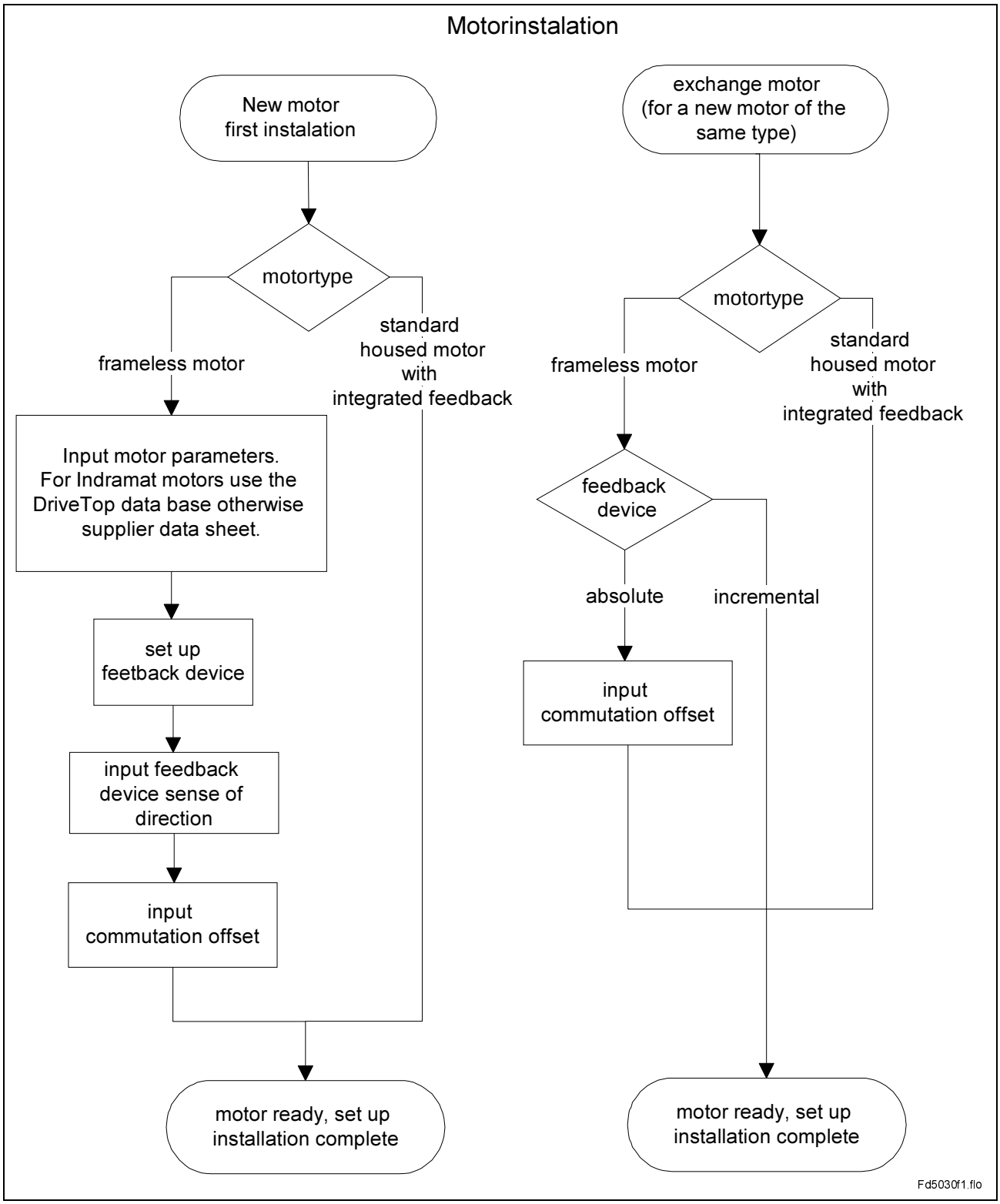



Fig. 7-7: Overview of starting up the motor

## Starting up Synchronous Kit Motors

Synchronous kit motors necessitate the additional setting of the following prior to start up:

- motor parameters must be input
- the motor encoder programmed (see section: "Motor Encoder"“).
- the rotational motion of the motor encoder must be set (see section: "Command Polarities and Actual Value Polarities")
- Commutation offsets.must be determined.

The motor parameters can be input via the motor data bank in the start up program DriveTop.

The commutation offset is determined with command **P-0-0524, D300 Commutation adjustment command.** This is done automatically in drives with an incremental motor encoder after the drive enable is applied.

(See also capter: "Determining commutation offset").

## Determining commutation offset

A condition for a constant torque through the complete motor rotation of a synchronous machine is the permanent offset setting between stator current vector and the rotor flow vector. If the angle between these two vectors $\gamma = 90°$, then the machine generates maximum torque. The synchronous machine is operated in this state.

To set the stator current vector see the information about absolute rotor positions. The difference between the motor position encoder (rotor raw position) and that of the absolute rotor position (in terms of the stator) is called the commutation offset. Once the offset is determined, the value is stored in parameter **P-0-0508, Commutation offset**.

When determining the offset at start up the difference is made between absolute and incremental measuring systems used as motor encoder.

**Motor with absolute measuring system:**

The motor has a motor encoder which makes the absolute rotor position known.

In this case it is necessary

- with the initial start up of the axis
- or after the measuring system has been replaced

to determine the commutation offset one time.

**WARNING**

**Fault in motor control and moving parts**

⇒ Commutation offset must be determined every time the mechanical reference between motor feedback and motor has changed. This is the case, for example, when the encoder or the motor have been exchanged.

**Motor with incremental measuring system:**

The motor is equipped with an incremental measuring system.

Rotor position is unknown every time the control voltage is switched on. Commutation offset must be determined with every transition into operating mode (e.g., after control voltage is switched on).

**Setting the motor encoder:**

This is automatic when the drive enable is applied.

With the help of **P-0-0074, Feedback 1 type** the measuring system type is parameterized. The following illustrates whether it is an absolute or incremental system.

| Value of P-0-0074, Feedback 1 type | Absolute rotor information |
|---|---|
| 1 | Yes |
| 2 | No |
| 3 | No |
| 5 | No |
| 8 | Yes |
| 9 | No |
| 10 | Yes |
| 11 | Yes |

Fig. 7-8: Absolute rotor information as dependent on encoder type

**How to determine the commutation setting:**

There are three different ways to determine the commutation offset outlined in the firmware. The following illustrates the relationship between the motor encoder used and the procedure used.

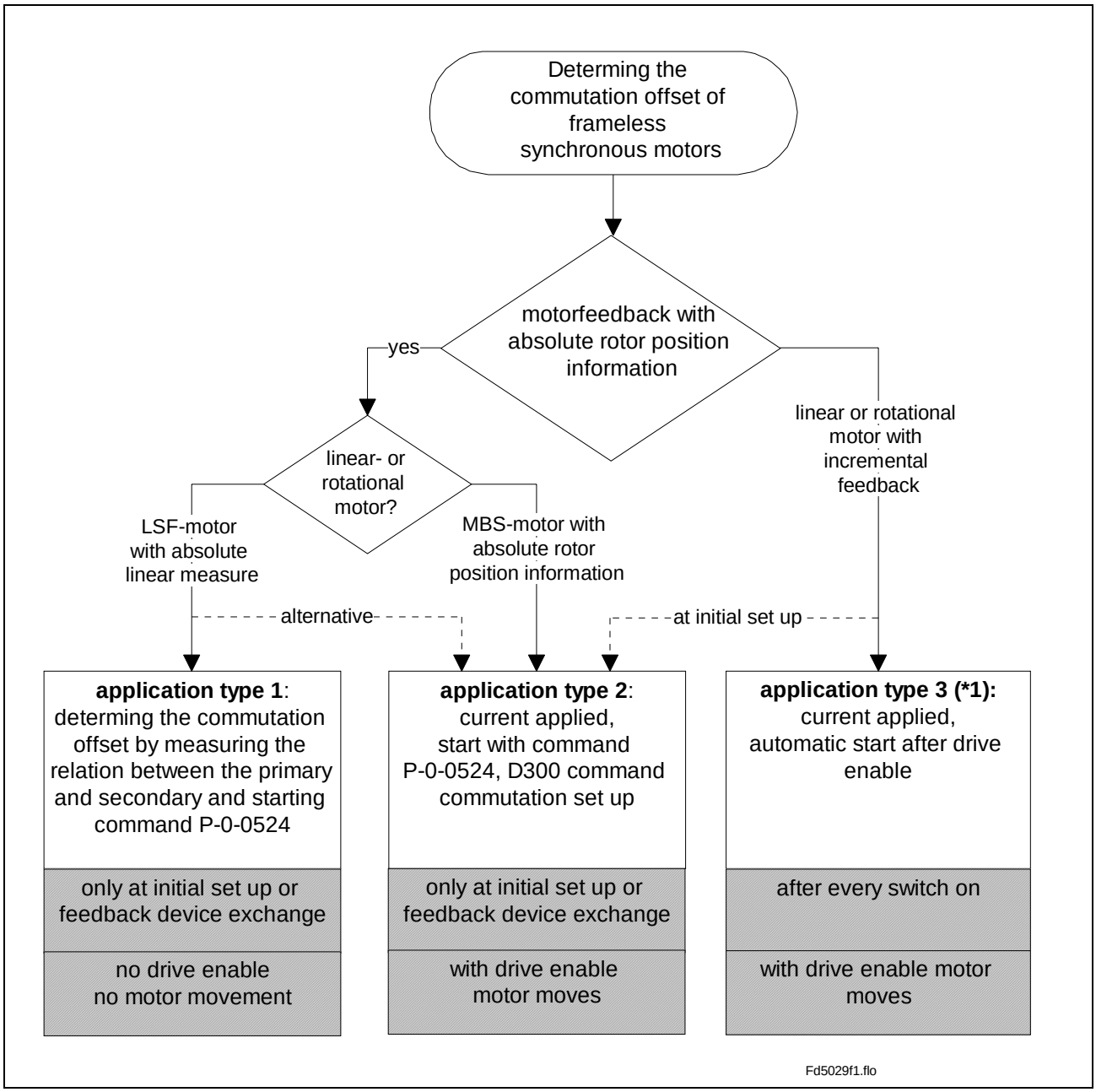

Determing the commutation offset of frameless synchronous motors
motorfeedback with absolute rotor position information
yes
linear- or rotational motor?
linear or rotational motor with incremental feedback
LSF-motor with absolute linear measure
MBS-motor with absolute rotor position information
alternative
at initial set up
application type 1: determing the commutation offset by measuring the relation between the primary and secondary and starting command P-0-0524
application type 2: current applied, start with command P-0-0524, D300 command commutation set up
application type 3 (*1): current applied, automatic start after drive enable
only at initial set up or feedback device exchange
only at initial set up or feedback device exchange
after every switch on
no drive enable no motor movement
with drive enable motor moves
with drive enable motor moves
Fd5029f1.flo

Fig. 7-9: Determining commutation offset in synchronous motors

**(*1)**

**DANGER**

Application no. 3 (synchronous motors with incremental encoder) **may not** be used in conjunction with the following applications:

-vertical axis without weight compensation („Hanging axes“)

-or a jammed or blocked axis.

⇒ **This application may only be used after the drive developer has been consulted and given permission!**

**Pre-requisites:** To successfully conduct this procedure, the following conditions must first be met:

- The rotational direction of the encoder must be set first:
  - for rotary motors:
    If the motor moves clockwise (looking onto motor drive shaft), then the value in parameter **S-0-0051, Position feedback 1 value** must be increasing.
  - for linear motors:
    If the primary part is moving to the direction of the front where the power cable of the motor branches off (see Fig. 7-11: Overview determining commutation offset with an LSF) then the value in parameter **S-0-0051, Position feedback 1 value** must be increasing.

  The position polarity in **S-0-0055, Position polarities** may not be inverted in this case. If the value moves in the wrong direction, then the motional direction of the motor encoder has to be inverted. Bit 3 of **S-0-0277, Position feedback 1 type** is used for this purpose.

  Also see section: "Command Polarities and Actual Value Polarities" or "Motor Encoder"“.
- The current and velocity control loop parameters must also have default settings or must be parameterized in a sensible way

## Application 1: Measuring the reference between primary and secondary parts (linear motors)

**Overview:** Determining commutation offset in linear synchronous motors (LSF) with absolute encoder systems can be determined by measuring the distance between the front of the primary part and the set screw of the motor secondary.

**Note:** Commutation offset is determined without axis motions.

**Parameters involved:**

- **P-0-0508, Commutation offset**
- **P-0-0523, Commutation, probe value**
- **P-0-0524, D300 Commutation adjustment command**

**Additional pre-requisites:** To successfully execute a command, the following additional conditions must be satisfied:

- The power cables of the motor must be correctly attached (correct rotation of the three phases).
- The drive must be in state **A013 Ready for power on**.
- A suitable primary part constant Kmx value must have been determined.

**Sequence:** Once the listed conditions have been met, then the value for parameter **P-0-0523, Commutation, probe value** is entered using the following formula:

$$P-0-0523 = d - K_{mx}$$

P-0-0523:Value determined for parameter P-0-0523
d: Measured value of distance between front of primary part and the secondary set screw
Kmx: Primary constant value

Fig. 7-10: Determining the value or commutation offset setting with linear servo motor (LSF).

**Note:** The distance is measured from the end which the motor power cable is not attached.

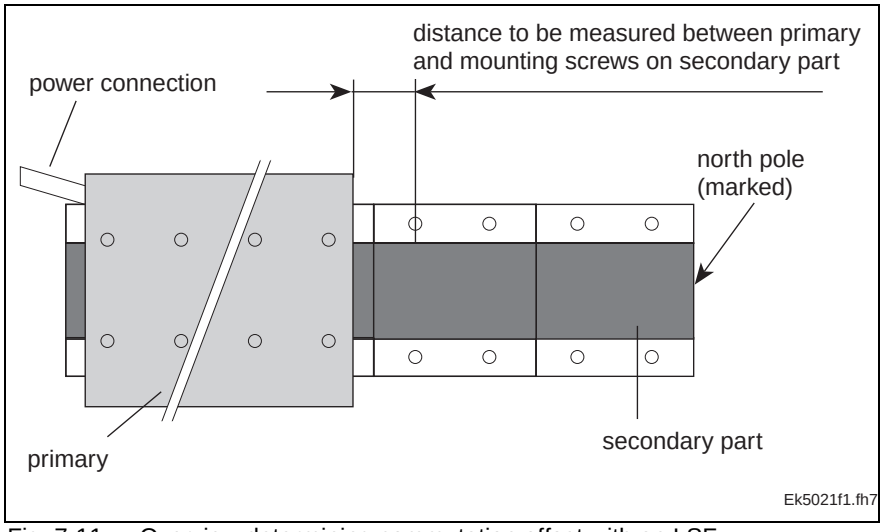



Fig. 7-11: Overview determining commutation offset with an LSF

After the value has been entered, it is necessary to start command **P-0-0524, D300 Commutation adjustment command**. The commutation offset is computed at this time.

**Note:** If the drive is in control at the time the command is started (i.e., drive enable is set and drive is in torque control mode), then the commutation offset is determined with current flow procedure (Application 2). (See „Alternative“ in Fig.: Determining commutation offset in synchronous motors).

The command must be reset to 0 at completion.

## Application 2: Current flow procedure, start using command P-0-0524, D300 Commutation adjustment command

DANGER

**The machine can be damaged if the procedure is performed incorrectly**

⇒ Restrictions noted in section: "Current flow procedure restrictions (Application 2 and 3)" must be taken into account.

**Used:** This procedure is used in the following situations:

- The commutation procedure must be completed only once, at first start up or when the encoder is exchanged on rotary synchronous motors with motor encoders containing absolute rotor position information.
- With linear motors with absolute encoder systems at initial start up as alternative to Application 1.
- With linear or rotary synchronous motors with incremental encoders this procedure should be used at initial start up of axis. In this case, parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time** are determined and stored in the drive. With each new start of the axis, the commutation must be determined if synchronous motors with incremental encoders are used. Application 3 is used to do this. As start values for the third procedure, the parameter values determined at the initial start up for **P-0-0560 and P-0-0562** are used.

**Parameters involved:**

- **P-0-0508, Commutation offset**
- **P-0-0524, D300 Commutation adjustment command**
- **P-0-0560, Commutation adjustment current**
- **P-0-0562, Commutation adjustment periodic time**

The following encoder types are available as motor encoders with absolute rotor position information:

| Values for P-0-0074, feedback 1 type with kit motors | Motor encoder interface |
|---|---|
| 1 | digital servo feedback (DSF) or resolver with feedback data memory |
| 8 | Heidenhain encoder with EnDat-Interface |
| 10 | Resolver without feedback data memory *) |
| 11 | Resolver + incremental encoder with sine signals without feedback data memory *) |

Fig. 7-12: Possible motor encoders for synchronous kit motors

Also see parameter description: **P-0-0074, Feedback 1 type**

**Note:** *) There is no feedback memory with this type of encoder. This is why the commutation offset is stored in parameter **P-0-0508, Commutation offset** in the programming module. Upon replacement of the module the value of parameter **P-0-0508, Commutation offset** has to be re-entered or the parameter from the old module must be saved and loaded into new module.

**More pre-requisites:** To execute this command, the drive must be in state **A012 Control and power sections ready for operation**. The 7-segment display reads „**Ab**“ in this case.

**Sequence:** To determine commutation offset the control sets command **P-0-0524, D300 Commutation adjustment command.** Upon completion of the command, the drive enable is shut off internally. To start the drive again, though, the control must complete the command and set the drive enable again.

The precise sequence is identical to the description in: "
Application 3: Current flow procedure, Automatic Sequence after applying drive enable".

## Application 3: Current flow procedure, Automatic Sequence after applying drive enable

**DANGER**

**The machine can be damaged if the procedure is performed incorrectly used**

⇒ Take the restrictions listed in section: "„
Current flow procedure restrictions (Application 2 and 3)" into account.

**Use with:** This procedure is automatically conducted in linear and rotary synchronous motors with incremental encoders systems whenever the unit is started up.

**Parameters involved:**

- **P-0-0508, Commutation offset**
- **P-0-0524, D300 Commutation adjustment command**
- **P-0-0560, Commutation adjustment current**
- **P-0-0562, Commutation adjustment periodic time**

**Sequence** The commutation offset only has to be re-determined if the motor encoder has been re-initialized. This is conducted while switching from parameterization into operating mode. The automatic commutation determined after applying drive enable thus only takes place if the drive power is turned off and switched back on again or if the drive was switched into parameterization mode.

After setting the drive enable, the motor moves rapidly for about 2 seconds to the left and right. The determined commutation offset is stored in parameter **P-0-0508, Commutation offset**.

If commutation offset has been successfully determined, the drive switches into the parameterized operation mode Diagnosis „AF“ is displayed. The drive simultaneously signals in parameter **S-0-0135, Drive status word** status „In operation under torque“.

**Note:** Maximum motion equals
Linear motor: +/- 1 pole width
Rotary motor: +/- 360 degrees / number of pole pairs

The drive starts the setting of the commutation offset with the values stored in parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time**. If commutation offset cannot be determined with these values, then they are changed and a new attempt is started. This means that first **P-0-0560, Commutation adjustment current** is increased to twice the motor standstill current. Then **P-0-0562, Commutation adjustment periodic time** is increased to 128 milliseconds.

**Note:** By changing the parameter values, the time that the drive needs for the commutation setting can increase considerable (up to two minutes).

**Initial start up**

This is why an initial start up is recommended. The values described above for **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time** are determined and stored in the parameter module. These are then available as start values for setting the commutation offset which is started after transition into operating mode. This means that the drive saves the time needed to determine the best parameter for the commutation setting.

Conducting the initial start up:

1. Switch drive into operating mode and power on.
2. Execute command **P-0-0524, D300 Commutation adjustment command**.

   The drive runs the commutation setting. At the end, the determined values are stored in the parameter memory in parameters **P-0-0560, Commutation adjustment current** and **P-0-0562, Commutation adjustment periodic time**. They can be used as start values for commutation settings in the future.

## Current flow procedure restrictions (Application 2 and 3)

**Restrictions when using holding brakes or clamps**

For the procedure it is necessary to ensure that the axis can move freely after drive enable is set by the control. If a holding brake or clamp is used, then it must be opened before the control sets the drive enable. This is guaranteed to occur if the holding brake is connected to the controller.

**DANGER**

**The machine can be damaged if the procedure is performed incorrectly.**

Procedure not to be used with

⇒ „Hanging axes“

⇒ Permanently clamped or blocked axes

**Restrictions with axes with dead stops**

Note the following with axes with dead stops:

**DANGER**

**The machine can be damaged if the procedure is performed incorrectly.**

⇒ Make sure that the axis is not at the dead stop when the drive enable is set.

**Peculiarities of Gantry axes**

Gantry axes require that the commutation is determined for each individual drive. This means that Gantry axes must be mechanically constructed so that each drive can run the arrangement.

If commutation is not yet known (after going from parameter mode into operating mode) then only one drive can generate the drive enable. The second or other axes must be torque free.

If the commutation setting of the first drive is over then it has to go torque free before the second drive of the axis (with commutation setting still applicable) sets the drive enable.

### Diagnoses

In conjunction with the commutation setting, the following diagnoses can occur:

- **D300 Command adjust commutation**

The commutation setting command is set. Determining commutation offset is running or has been executed.

- **D311 Commutation offset could not be determined.**

Or

- **F811 Commutation offset could not be determined.**

Commutation offset has not been determined because:

- encoder rotational direction was wrong
- axis mechanically blocked
- brake closed
- axis at dead stop

- **D301 Drive not ready for commutation command**

At command start (Application 2) the drive must be in **torque control.** If not, then this error is generated.

- **D312 Motion range exceeded during commutation**

Or

- **F812 Motion range exceeded during commutation**

The axis has moved more than one pole width or 360° / number of pole pairs because:

- Parameter for commutation setting is too big
- mechanical motion generated from outside
- velocity controller incorrectly parameterized

## Fieldweakening range for synchronous motors

The working range of synchronous motors is limited in conventional mode on converters by the converter voltage. The motor reaches maximum speed once its no-load voltage has reached the converter voltage.

With a fieldweakening range for synchronous motors it has become possible to operate motors outside of this limitation.

If fieldweakening is to be used with synchronous motors then the following parameters must be set motor-specifically as stated in the Indramat specifications:

- **P-0-4004, Magnetizing current**
- **P-0-0531, Stall current factor**
- **P-0-0533, Flux loop prop. gain**
- **P-0-0534, Flux loop integral action time**
- **P-0-0535, Motor voltage at no load**
- **P-0-0536, Motor voltage max.**
- **P-0-0532, Premagnetization factor**
- **P-0-0538, Motor function parameter 1**

**Note:** The motor must be suited for operating in the fieldweakening range.

The fieldweakening function for synchronous motors is activated with parameter **P-0-0538, Motor function parameter 1**.

# 7.5 Motor Holding Brake

A motor holding brake can be mounted via a potential-free contact built into the drive controller . It prevents unwanted axis movements when the drive enable signal is off. (e.g. for a vertical axis without a counterweight)

**Note:** The holding brake for Rexroth Indramat motor types MHD and MKD is not a working brake. It wears down after about 20,000 motor revolutions if the brake is closed.

**DANGER**

**Dangerous movements! Danger to personnel from falling or dropping axes!**

⇒ The standard equipment motor brake or an external brake controlled directly by the servo drive are not sufficient to guarantee the safety of personnel!

⇒ Personnel safety must be acquired with higher-ranking procedures:

Dangerous areas should be blocked off with fences or grids.

Secure vertical axes against falling or slipping after switching off the motor power by, for example:

- Mechanically securing the vertical axes
- Adding an external brake / clamping mechanism
- Balancing and thus compensating for the vertical axes mass and the gravitational force

## Pertinent Parameters

To set the motor holding brake, use parameters

- **P-0-0126, Maximum braking time**
- **P-0-0525, Type of motor brake**
- **P-0-0526, Brake control delay**
- **P-0-0538, Motor function parameter 1**
- **P-0-0540, Torque of brake**
- **P-0-0541, B200 Brake check command**
- **P-0-0542, B100 Command Release motor holding brake**

**The parameters for the motor holding brake are automatically set in motors with motor feedback data memory**

Parameters **P-0-0525** and **P-0-0526** are automatically set in MHD, MKD and MKE motors. For all other motor types, the values which must be entered are specified in the data sheet of the motor or the motor brake. Parameter **P-0-0126** must be parametrized to meet machine requirements.

# Setting the Motor Brake Type

Using parameter **P-0-0525, Type of motor brake** it is possible to set the motor brake type.

It must be identified in terms of:

- self-releasing or self-holding brake
- spindle brake or servo brake

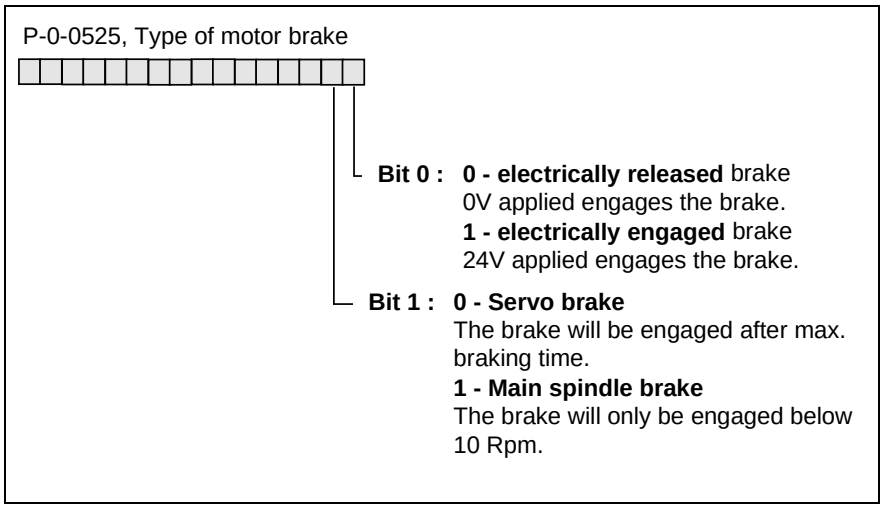

P-0-0525, Type of motor brake
Bit 0 : 0 - electrically released brake
0V applied engages the brake.
1 - electrically engaged brake
24V applied engages the brake.
Bit 1 : 0 - Servo brake
The brake will be engaged after max. braking time.
1 - Main spindle brake
The brake will only be engaged below 10 Rpm.

Fig. 7-13: Setting the motor brake type

**The behavior with a spindle brake**

**P-0-0525, Type of motor brake**

**bit 1 = 1**

Activating the motor holding brake always takes place with drive enable removed if the actual velocity of the motor is smaller than 10 rpm or 10mm/min (linear motor).

At the end of maximum decel time (P-0-0126) the set error reaction is completed and the drive goes torque free.

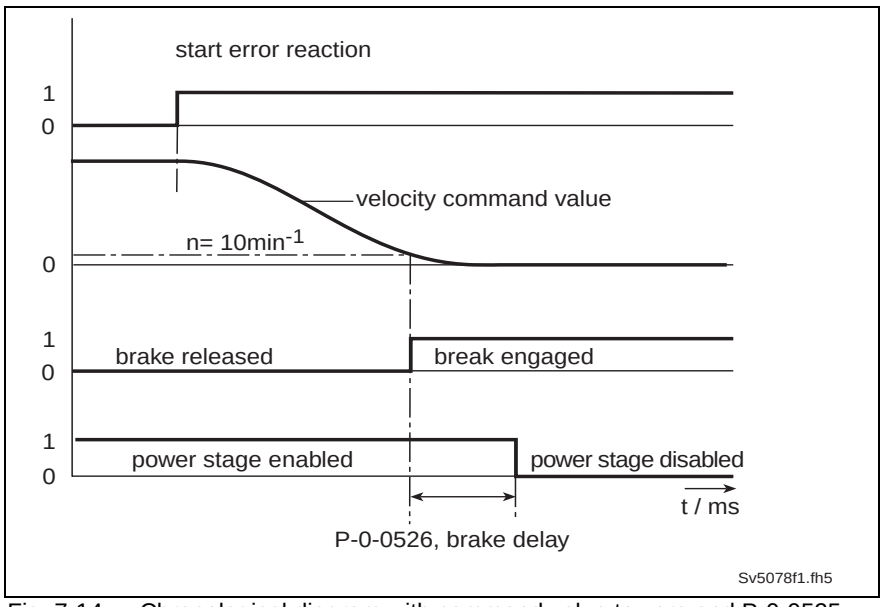



Fig. 7-14: Chronological diagram with command value to zero and P-0-0525, Holding brake type, **Bit 1 = 1** (Spindle brake)

**Behavior with servo brake**

**P-0-0525, Type of motor brake**

**bit 1 = 0**

**braking time < P-0-0126**

The brake is activated:

- as soon as the velocity of 10 rpm is exceeded during an error reaction or
- no later than upon completion of the maximum decel time.

Correct braking time

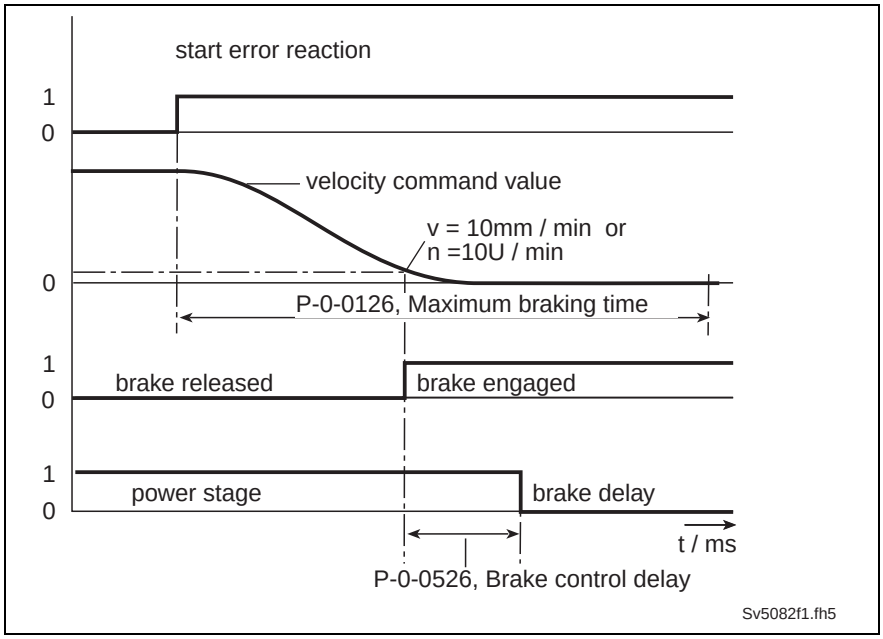



Fig. 7-15: Chronological diagram with command value to zero and P-0-0525, Holding brake type, Bit 1 = 0 (Servo brake) and actual braking time < P-0-0126

**Behavior with servo brake**

**P-0-0525, Type of motor brake**

**bit 1 = 0**

**braking time > P-0-0126**

Incorrect braking time

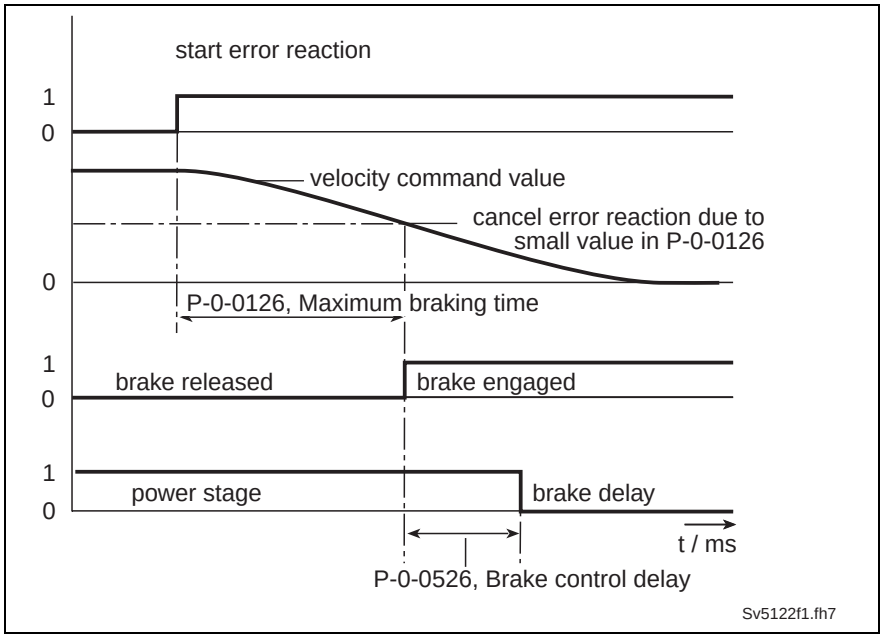



Fig. 7-16: Chronological diagram with command value to zero and P-0-0525, Holding brake type, Bit 1 = 0 (Servo brake) and actual braking time > P-0-0126

## Setting the Motor Brake Integral Action Time

In **P-0-0526, Brake control delay** it is necessary to set the time that the motor brake control needs to actually apply the brake.

**Note:** A standard value for the direct connection of holding brakes of Rexroth Indramat motors equals 150msec.

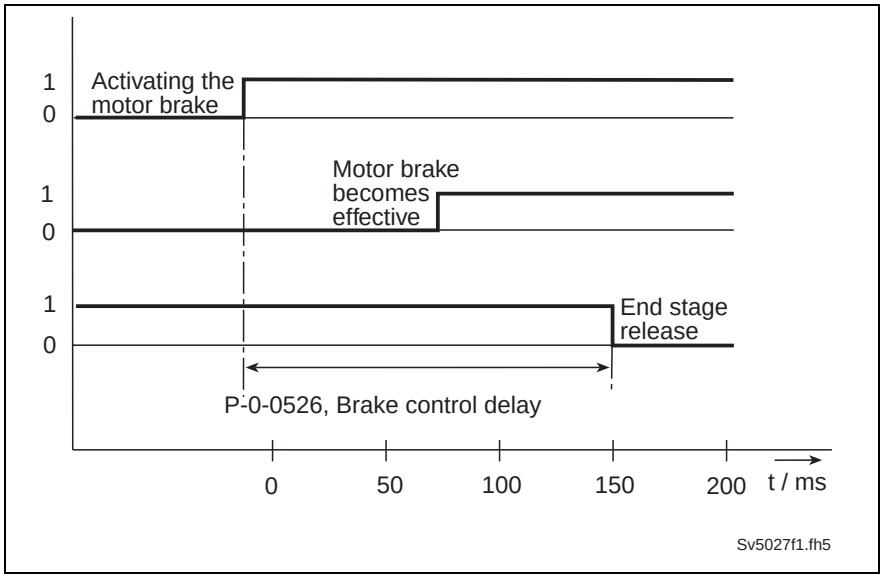



Fig. 7-17: Setting motor brake integral action time

## Setting Maximum Decel Time

Parameter **P-0-0126, Maximum braking time** supports decel time monitoring and activation of the motor holding brake if the theoretical decel time is exceeded due to an error.

The motor holding brake is activated if the time since the start of the error reaction exceeds the time set in **P-0-0126, Maximum braking time**.

**Note:** The value in P-0-0126, Maximum braking time must be set so that the drive can come to a standstill with the greatest possible moment of inertia and force from maximum speed.

**ATTENTION** If the value in **P-0-0126, Maximum braking time** is too small, then the error reaction is terminated and the motor holding brake activated at a speed greater than 10 UPM. This will damage the brake if permitted to continue over extended periods of time!

## Command Release motor holding brake

The open holding brake command as specified in **P-0-0542, B100 Command Release motor holding brake** is used to release the holding brake if the drive enable has been switched off.

First, the command must be enabled using bit 9 in the **P-0-0538, Motor function parameter 1**.

The motor holding brake is opened upon activation of the command.

Upon completion of the command, the brake is again applied. Given an active command to switch drive enable on and off, then the brake is again closed.

**ATTENTION**

Releasing the holding brake on a vertical axis may lead to unwanted motion.

## Monitoring the Motor Holding Brake

The holding brake monitor can be executed each time the drive enable is switched off or on or by executing command "Brake monitor". An automatic check necessitates that bit 10 is set in motor function parameter (**P-0-0538, Motor function parameter 1**).

### Automatic Checks

**Applying drive enable**

When applying the drive enable, the opening of the brake is checked. This means that the drive is run at maximum decel nominal torque.

If it is possible to move the motor at nominal brake torque, then the brake has opened as it should.

If the motor cannot be moved, then the brake is closed. Error **F269 Error when releasing the motor holding brake** is generated.

**Removing drive enable**

When switching drive enable off, the holding torque of the brake is checked. This means that the nominal brake torque is applied to the motor with the brake closed.

If no movement is possible, then the brake is in order.

If the motor moves during the check, then warning **E269 Brake torque too low** is generated.

The warning remains pending until the monitor recognizes one of the brakes as alright.

### Command brake monitor

With the activation of the command, it is first checked whether the motor can be moved with a torque that is smaller than the nominal brake torque.

If this is not possible, then the motor holding brake is closed.

Error **F269 Error with motor brake release** is generated.

If movement is possible, then the nominal brake torque is generated by the motor with closed brake.

If the motor does not move, then the brake is functional. With movement, the attempt is made to again achieve the holding torque of the brake by looping in the brake. After this procedure, the holding torque is again checked. If nominal torque is again not achieved, then command error **B203 Brake torque too low** is generated.

**ATTENTION**

A monitoring of the holding brake generates axis movements.

## Connecting the Motor Holding Brake

See relevant Project Planning Manual for details.

# 8 Operating Modes

## 8.1 Setting the Operating Mode Parameters

To program operating modes use parameters:

- **S-0-0032, Primary Mode of Operation**
- **S-0-0033, Secondary Operating Mode 1**
- **S-0-0034, Secondary Operating Mode 2**
- **S-0-0035, Secondary Operating Mode 3**

**Automatic programming of operating mode parameters by selecting a profile type**

Main and auxiliary modes are automatically set depending on the value in **P-0-4084, Profile type**. Only if profile type "free programmable operating mode" (**P-0-4084, Profile type** = 0xFFFE), can parameters S-0-0032..35 be freely programmed.

(see also chapter: "Profile Types")

**Note:** The parameter description offers an overview of possible input values for the above listed parameters.

## 8.2 Determining/detecting the active mode

The selection of active operating modes depends on how parameter **P-0-4084, Profile type** has been programmed.

If profile types:

- I/O mode with block acknowledge (P-0-4084 = 0xFF80),
- I/O mode with cam status (P-0-4084 = 0xFF81) or
- I/O mode freely expandable (P-0-4084 = 0xFF82)

**Activation dependent on operating mode and profile types set**

are set, then there is only the choice of positioning block mode ( = Primary Mode of Operation) and jog mode ( = Secondary Operating Mode 1). The selection is specified via bits 6 (jog positive) and 7 (jog negative) in **P-0-4077, Fieldbus control word**.

If profile types

- drive-internal interpolation (P-0-4084 = 0xFF91),
- cyclic position control with encoder 1 (P-0-4084 = 0xFF92),
- velocity control (P-0-4084 = 0xFF93) or
- freely configurable operating mode (P-0-4084 = 0xFFFE)

are set, then transition between primary and 3 secondary operating modes is possible without restrictions. The switch is set in bits 8 and 9 (command mode) in **P-0-4077, Fieldbus control word**. In this case, the actually active modes are displayed in bits 8 and 9 in **P-0-4078, Fieldbus status word**.

**Note:** If 0 is entered in one of the operating mode parameters and that operating mode is activated, then the error **F207 Switching to a non-initialized operation mode** will be generated.

The fieldbus control word is always the first word to be transmitted in the real time channel.

# 8.3 Operating Mode: Torque Control

**Note:** With FGP firmware this is only possible in conjunction with analog operations. (P-0-4084 = 0xFFFE).

In the operating mode **torque control** the drive is given a torque command value. The diagnostic message reads **A100 Drive in TORQUE control** when this operating mode is active.

The command value is set in parameter **S-0-0080, Torque/Force command**.

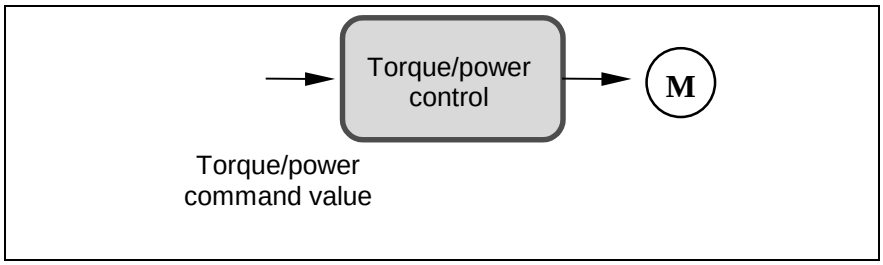



Fig. 8-1: Block diagram of torque control

## Pertinent Parameters

- **S-0-0080, Torque/Force command**
- **P-0-4046, Active peak current**
- **P-0-0176, Torque/Force command smoothing time constant**

## Torque Control

The command value in **S-0-0080, Torque/Force command** is limited with the effective peak current **P-0-4046, Active peak current**. This current is based on the current and torque limits.

(See section: "Current Limit" and "Torque Control").

The limited torque command value is filtered through a 1st order filter. The time constant of the filter is set in parameter **P-0-0176, Torque/Force command smoothing time constant**.

After limiting and filtering, the effective torque-generating command value is generated. It is the command value for the effective current control.

Using „Analog output of predefined signals“ the effective command current can be output as an analog value.

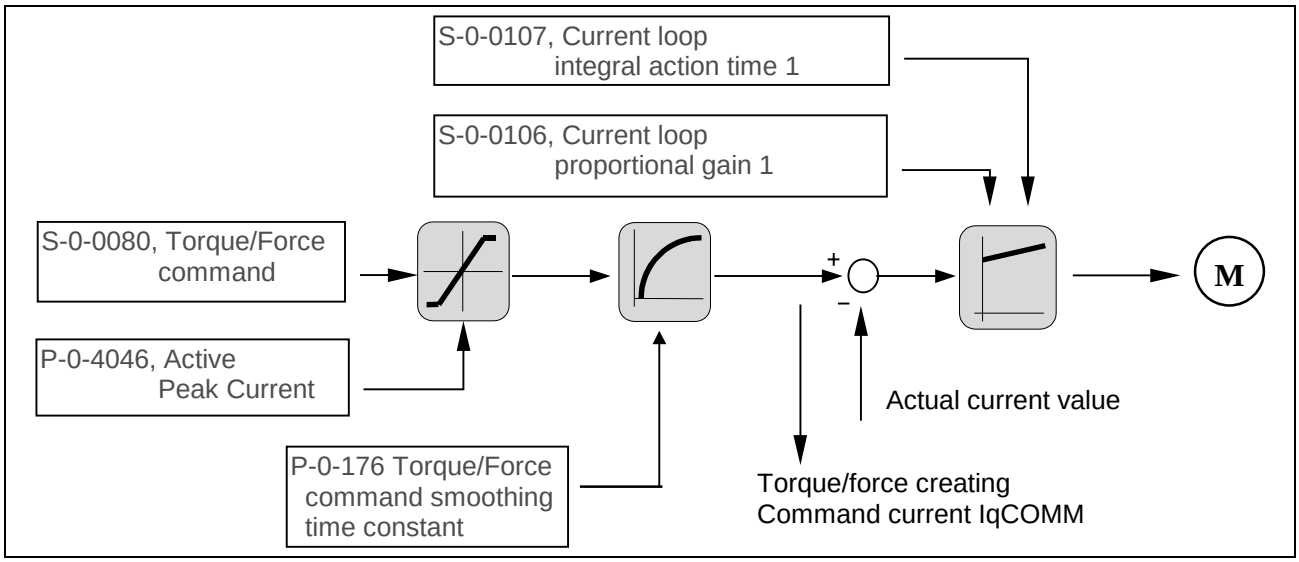



Fig. 8-2: Torque control

## Diagnostic Messages

Operating mode-specific monitors are

- Monitoring actual velocity for a 1.125 fold value of parameter **S-0-0091, Bipolar velocity limit value**.

(See section: "Limiting to Bipolar Velocity Limit Value").

If this value is exceeded, then error **F879 Velocity limit S-0-0091 exceeded** is generated.

# 8.4 Operating Mode: Velocity Control

**Note:** This operating mode is activated with the selection of profile P-0-4084 = 0x0003 or P-0-4084 = 0xFF93 or with analog operations with P-0-4084 = 0xFFFE

A velocity value is commanded to the drive in the **Velocity Control** operating mode. The velocity command value is limited with ramps and a filter. The diagnostic message reads **A101 Drive in Velocity Mode** when this operating mode is active.

The command values are specified in the parameters **S-0-0036, Velocity command value** and **S-0-0037, Additive velocity command value**.

## Pertinent Parameters

- **S-0-0037, Additive velocity command value**
- **S-0-0036, Velocity command value**
- **S-0-0091, Bipolar velocity limit value**
- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**
- **P-0-1211, Deceleration ramp 1**
- **P-0-1213, Deceleration ramp 2**
- **P-0-1222, Velocity command filter**

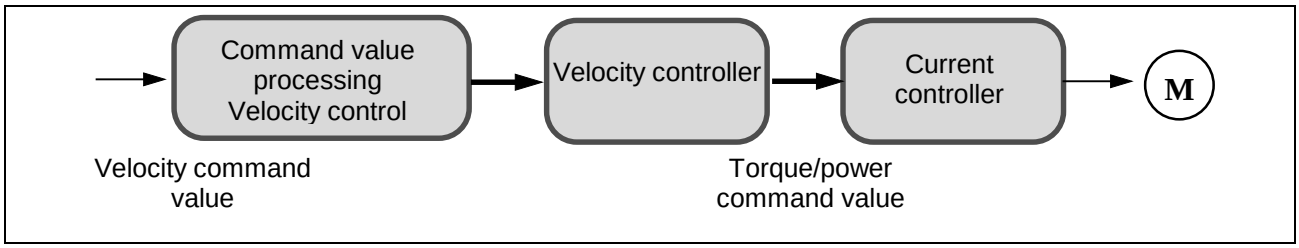



Fig. 8-3: Velocity control block diagram

## Command value processing Velocity control

The given **S-0-0036, Velocity command value** is limited to **S-0-0091, Bipolar velocity limit value**. If the command value is higher, the message **E263 Velocity command value > limit S-0-0091** is shown. The command value is then accel limited via **P-0-1201, Ramp 1 pitch**. If command velocity exceeds the velocity in parameter **P-0-1202, Final speed of ramp 1,** then the command value is accel limited in terms of value **P-0-1203, Ramp 2 pitch**. Parameters **P-0-1211, Deceleration ramp 1** or . **P-0-1213, Deceleration ramp 2** are used for the decels. This means that for accel and decel procedures various ramps can be used. The limit velocity command is jerk limited by means of a filter of the 1st order (**P-0-1222, Velocity command filter)**.

If parameters **P-0-1211, Deceleration ramp 1** or **P-0-1213, Deceleration ramp 2** are equal to zero, then parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** used.

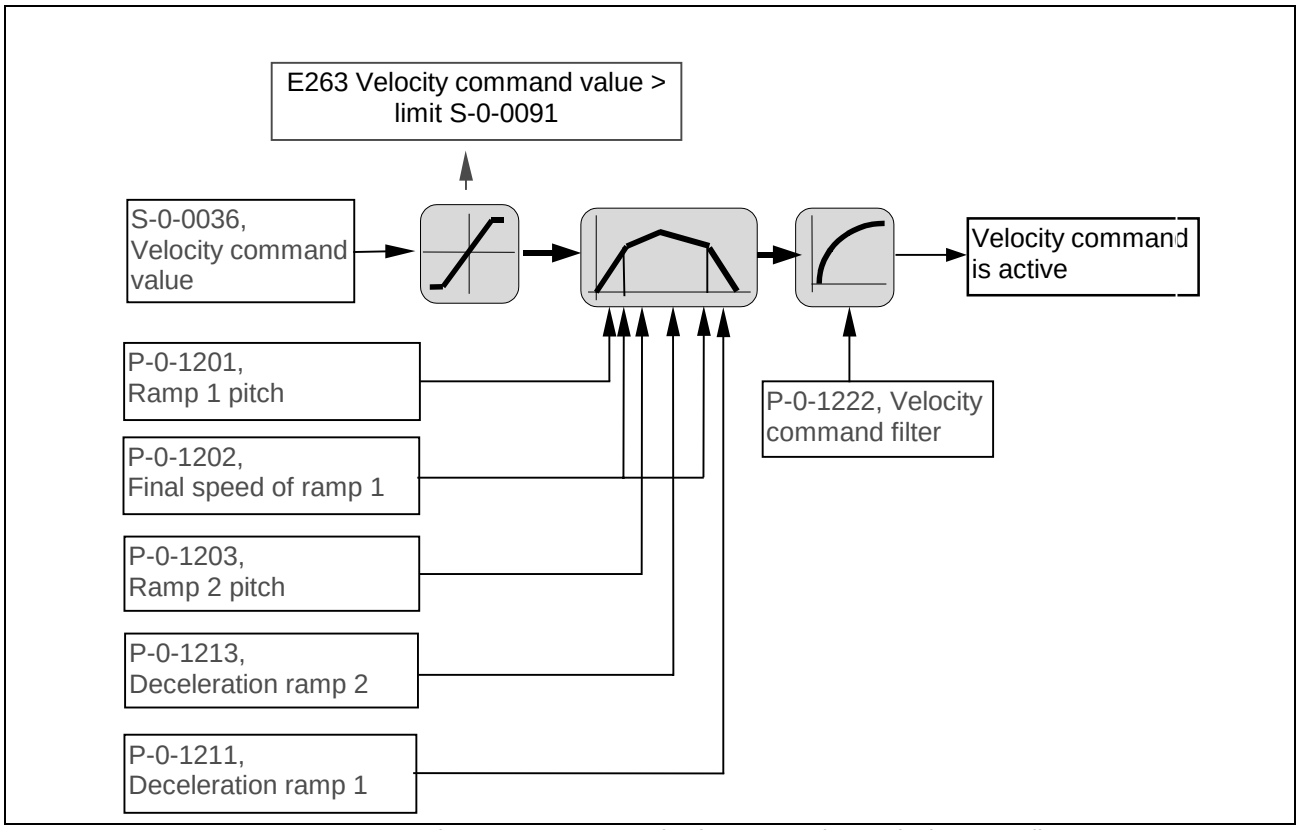

E263 Velocity command value > limit S-0-0091
S-0-0036, Velocity command value
Velocity command is active
P-0-1201, Ramp 1 pitch
P-0-1202, Final speed of ramp 1
P-0-1203, Ramp 2 pitch
P-0-1213, Deceleration ramp 2
P-0-1211, Deceleration ramp 1
P-0-1222, Velocity command filter

Fig. 8-4: Command value processing: Velocity Controller

See also chapter: "Velocity Controller"

See also chapter: "Current Controller".

## Velocity Controller

The effective velocity command value is added with **S-0-0037, Additive velocity command value**.

Further it is limited to **S-0-0091, Bipolar velocity limit value**.

(See also chapter: "Limiting to Bipolar Velocity Limit Value")

If the resulting command value is at the limit, the warning **E259 Command velocity limit active** is displayed.

The velocity control difference is produced by including the feedback velocity in the control loop. The unfiltered feedback velocities of the motor and, if available, the external encoder can be combined into an effective actual velocity value. (See also chapter: "Setting the Velocity Mix Factor".)

Via **P-0-0004, Velocity loop smoothing time constant** you can limit the band of the control difference for the velocity controller.

This variable is then relayed to the current and torque limits.

(See also chapter: "Current Limit" and "Torque Limit".)

To filter mechanical resonance frequencies, a notch filter can be applied to this torque/force command value. Using parameter **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop** the frequency range which must be suppressed can be parametrized.

(See also "Setting the Velocity Controller".)

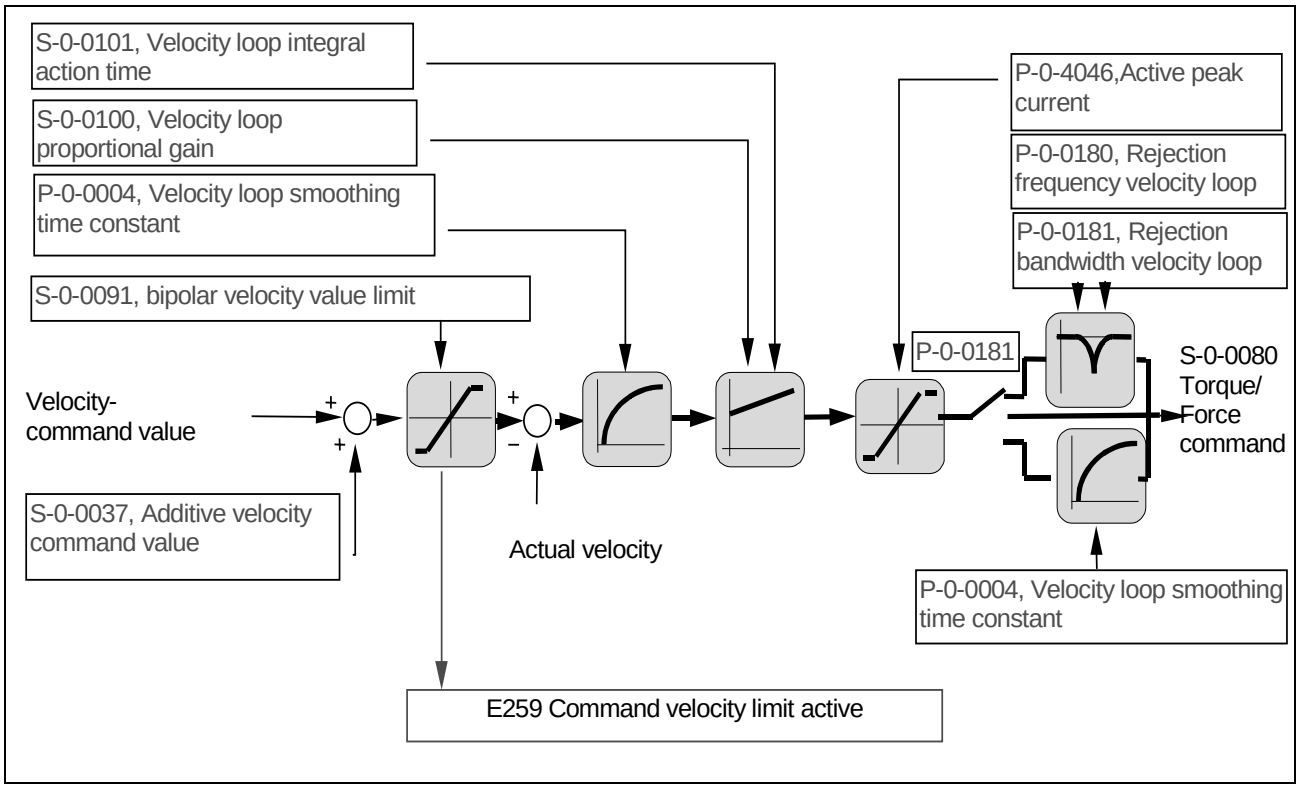

S-0-0101, Velocity loop integral action time
S-0-0100, Velocity loop proportional gain
P-0-0004, Velocity loop smoothing time constant
S-0-0091, bipolar velocity value limit
P-0-4046,Active peak current
P-0-0180, Rejection frequency velocity loop
P-0-0181, Rejection bandwidth velocity loop
P-0-0181
S-0-0080 Torque/ Force command
Velocity- command value
S-0-0037, Additive velocity command value
Actual velocity
P-0-0004, Velocity loop smoothing time constant
E259 Command velocity limit active

Fig. 8-5: Velocity Controller

See also chapter: "Command value processing Velocity control"

See also chapter: "Current Controller".

## Current Controller

The current controller is parameterized with **S-0-0106, Current loop proportional gain 1** and **S-0-0107, Current loop integral action time 1**.

(See also chapter: "Setting the Current Controller".)

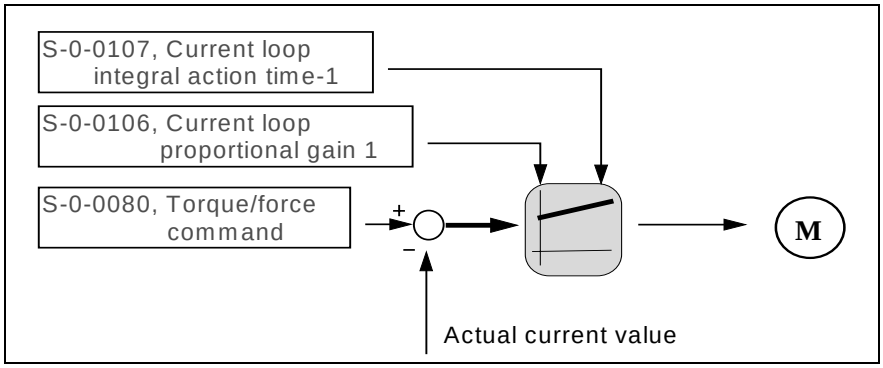



Fig. 8-6: Current Controller

## Diagnostic Messages

Operating mode specific monitors are

- **E259 Command velocity limit active**
  If the resulting command value is in the limit, then warning **E259 Command velocity limit active** is displayed.
- **E263 Velocity command value > limit S-0-0091** .
  Parameter **S-0-0036, Velocity command value** is set to the value of parameter **S-0-0091, Bipolar velocity limit value**. The warning **E263 Velocity command value > limit S-0-0091** is generated.

# 8.5 Operating Mode: Position Control

**Note:** The operating mode is activated in the drive with profile types P-0-4084 = 0xFF92 and possibly P-0-4084 = 0xFFFE.

A position value is commanded to the drive every NC-cycle time in the **Position Control** operating mode. The timebase is defined here in **S-0-0001, NC Cycle time (TNcyc)**. When this mode is activated, the diagnostic message is one of the following:

- **A102 Position Control Encoder 1**
- **A103 Position Control Encoder 2**
- **A104 Position Control Encoder 1 Lagless Positioning**
- **A105 Position Control/ Encoder 2 / Lagless Positioning**

The command value is specified in the parameter **S-0-0047, Position Command Value** .

Monitors specific to this operating mode are:

- Monitoring the command velocity versus the value of the parameter **S-0-0091, Bipolar velocity limit value**.

If this value is exceeded, the error **F237 Excessive position command difference** is generated.

The command value specified in **S-0-0047, Position Command Value** is interpolated within the NC cycle time and is then given to the position controller.

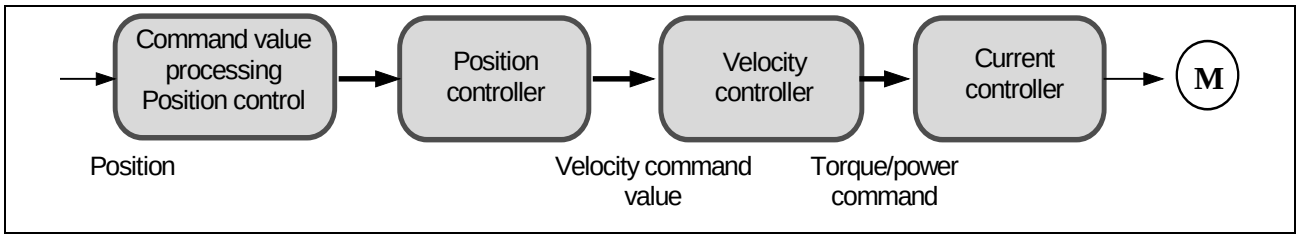



Fig. 8-7: Position control block diagram

## Command value processing: Position Control

A command velocity is formed from two successive position command values. The **S-0-0001, NC Cycle Time (TNcyc)** acts as the time base.

The instructions for calculating the command velocity are as follows:

$$Vcommand = \frac{Position\,command\,value(k) - Position\,command\,value(k-1)}{S-0-0001}$$

Vcommand: Command velocity

Fig. 8-8: Calculating the command velocity

This velocity is monitored to see if it exceeds **S-0-0091, Bipolar Velocity Limit Value** (see also: "Position Command Value Monitoring". If **S-0-0091** is exceeded, the error **F237 Excessive position command difference** is generated.

The commanded position profile can be filtered with the parameter **P-0-0099, Position command smoothing time constant**.

The position loop is closed every 1000usec. The position command value is also fine interpolated within the NC cycle time.

There is either a linear or a cubic interpolator available. Switching between the two is implemented through bit 0 of **P-0-0187, Position command value processing mode**. In general the cubic interpolator is recommended unless the timing behavior of the linear interpolator is required (see parameter description of P-0-0187). The cubic interpolator is superior to the linear one in particular with lagless position control because it offers a clearly higher quality of the velocity- and acceleration feedforward precontrol.

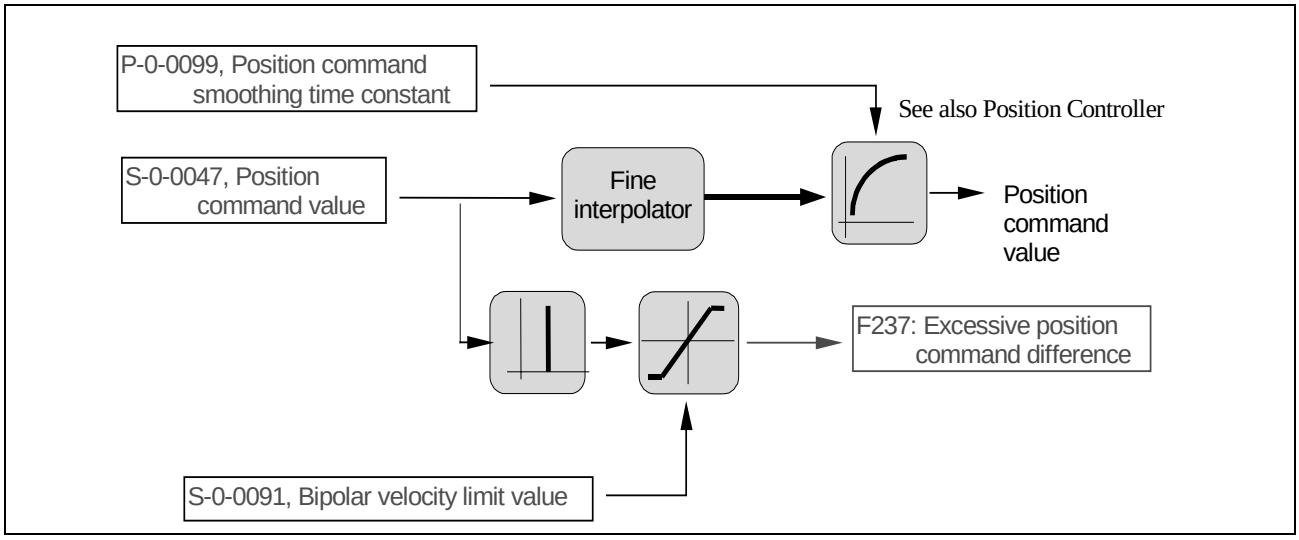

P-0-0099, Position command smoothing time constant
See also Position Controller
S-0-0047, Position command value
Fine interpolator
Position command value
F237: Excessive position command difference
S-0-0091, Bipolar velocity limit value

Fig. 8-9: : Command value processing: position control

See also "Current Controller"

See also "Velocity Controller"

See also "Position Controller"

# Position Controller

The position controller error is computed from the effective position command value from the generator function of the active operating mode and the position feedback value (encoder 1 or encoder 2) used for the controller.

This is given to the position controller, whose control loop gain is set with **S-0-0104, Position Loop Kv-Factor**.

Bit 3 in the operating mode parameters (S-0-0032..35) indicates if positioning should be subject to the following errors.

Definition of bit 3 of operating mode parameters (S-0-0032 to S-0-0035)

| | | |
|---|---|---|
| Bit 3=1 | lagless | (with velocity precontrol) |
| Bit 3=0 | with lag | (without velocity precontrol) |

With lagless position control, an acceleration feed forward component can be included with parameter **S-0-0348, Acceleration Feedforward prop. Gain**.

(See also: "Setting the Acceleration Feed Forward".)

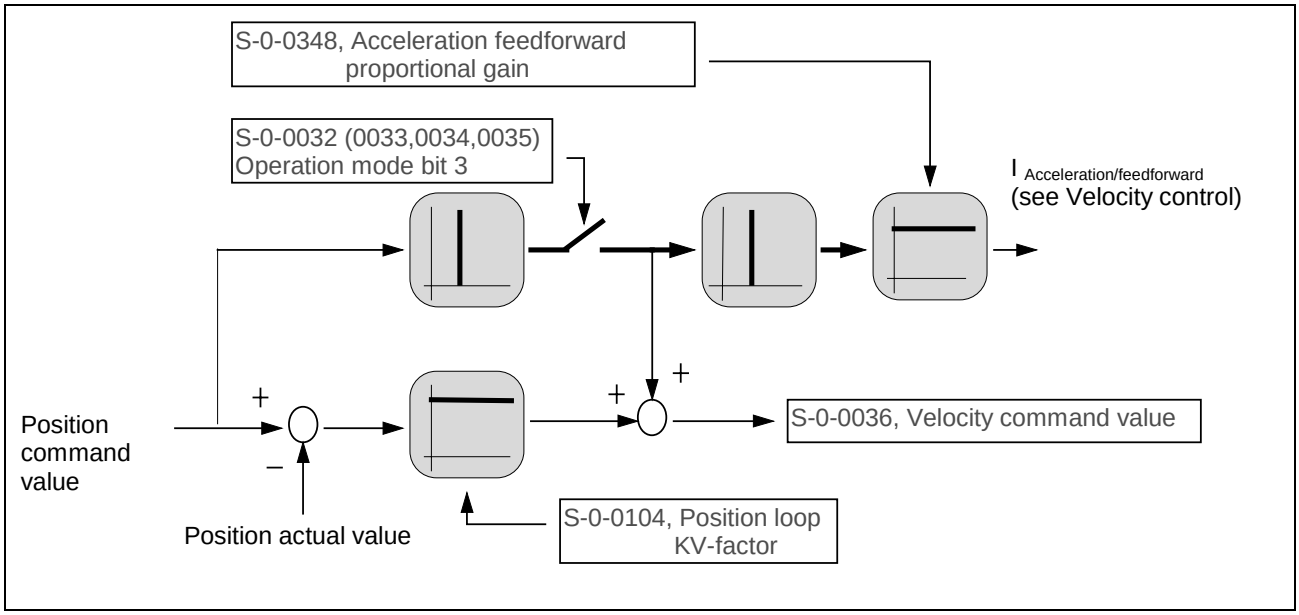



Fig. 8-10: Position controller

See also "Current Controller"

See also "Velocity Controller"

## Position Command Value Monitoring

If the drive is operated in the position control mode with cyclical position commands, new position values are transmitted to the drive every NC cycle **(S-0-0001, NC Cycle time (TNcyc)**. The difference between the current and the last position command value is checked for validity.

Reasons monitoring is activated:

- Erroneous control system command values
- Command value transmission error

If the **Position Control** operating mode is active, the velocity produced by the difference in successive values of parameter **S-0-0047, Position Command Value** is compared to

- **S-0-0091, Bipolar Velocity Limit Value**

**S-0-0001, NC Cycle Time (TNcyc)** acts as the time base for converting the position command value differences into a velocity.

If the command velocity resulting from the position command value exceeds **S-0-0091, Bipolar Velocity Limit Value**, the error

- **F237 Excessive position command difference**

is generated. For diagnostic purposes, both of the parameters

- **P-0-0010, Excessive Position Command Value**
- **P-0-0011, Last valid Position Command Value**

will be saved. The velocity produced by the difference of the two values generated the error.

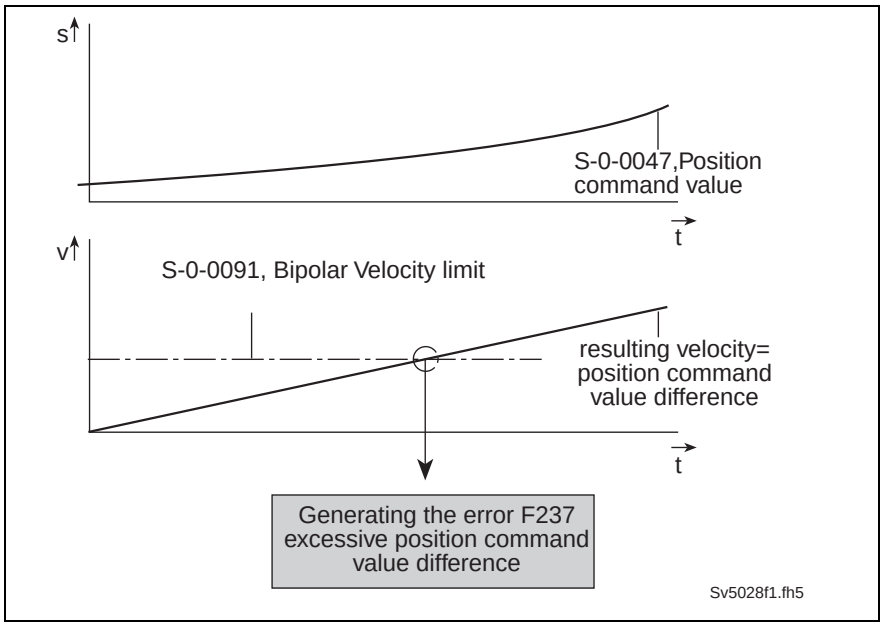



Fig. 8-11: Monitoring the position command value differences and generating the error **F237 Excessive position command difference**

## Setting Position Command Value Monitoring

The position command value monitor works with the parameter **S-0-0091, Bipolar Velocity Limit Value**. It should be set to approximately 5 to 10% above the planned maximum velocity of the motor.

# 8.6 Operating Mode: Drive Internal Interpolation

**Note:** The operating mode becomes effective in the drive at the time that the profile is selected with P-0-4084 = 0xFF91. The target position must be programmed via parameter **S-0-0258, Target position.** The target position is then immediately assumed.

The drive is given a target position in **Drive Internal Interpolation** mode. The drive now runs to the programmed target position while maintaining positioning velocity, positioning acceleration and the positioning jerk.

## Pertinent Parameters

For the motion calculation the following are used:

- **S-0-0108, Feedrate override**
- **S-0-0193, Positioning Jerk**
- **S-0-0258, Target position**
- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**
- **S-0-0393, Command value mode**

For the status display the following parameter is used:

- **S-0-0182, Manufacturer class 3 diagnostics**

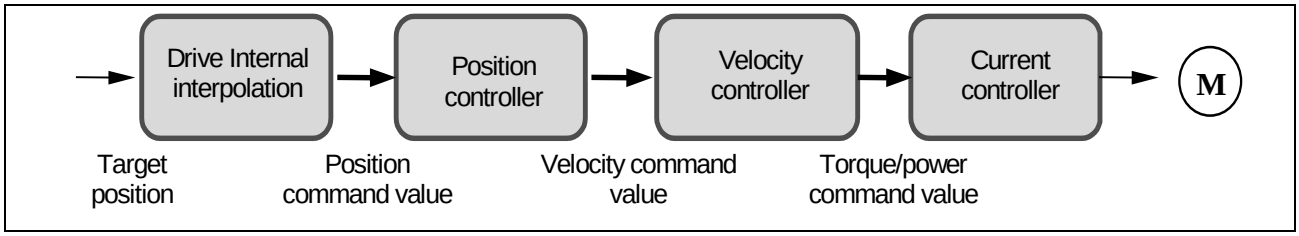



Fig. 8-12: Drive-internal interpolation diagram

## Functional Principle

The target position can be cyclically programmed via parameter **S-0-0258, Target position**.

**Note:** The control bits contained in S-0-0393 (bit3 and Bit4) are meaningless in this operating mode.

The drive generates the position command profile necessary to move to the target position using the following parameters as limits:

- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**
- **S-0-0193, Positioning Jerk**
- **S-0-0108, Feedrate override**

**Effective positioning velocity**

The maximum velocity achieved by the drive after an acceleration phase with the value set in **S-0-0260, Positioning Acceleration**.

The maximum velocity during a positioning procedure is the result of:

$$V_{max} = S-0-0259, \text{Positioning Acceleration} * \frac{S-0-0108, \text{ Feedrate override}}{100\%}$$

**Effective accel and decel**

The maximum delay is fixed in parameter **S-0-0359, Positioning Deceleration**.

If parameter **S-0-0359, Positioning Deceleration** equals zero, then the drive uses parameter **S-0-0260, Positioning Acceleration** for decel as well.

**CAUTION**

**Damage to property with wrong parametrization**

If the values for positioning decel and accel are zero, then the drive cannot brake. The set target is never reached or is overrun.

⇒ Always enter for positioning accel a value of > 0.

**Smoothing filter (or jerk filter)**

Accel and decel are smoothed by using a jerk limit value and PT1 filtering. This means that accel or decel do not become effective until after t= 5*$T_{R.}$

The time constant $T_R$ of the smoothing filter (jerk filter) results from:

$$T_R = \frac{S-0-0260, \text{ Positioning Acceleration}}{S-0-0193, \text{ Positioning Jerk}}$$

or

$$T_R = \frac{S-0-0359, \text{ Positioning Deceleration}}{S-0-0193, \text{ Positioning Jerk}}$$

**Note:** For the accel or decel procedure only one time constant, namely the biggest one in the above equation, is always used.

**S-0-0193, Positioning Jerk = 0** switches the smoothing filter off, the desired accel or decel is reached directly.

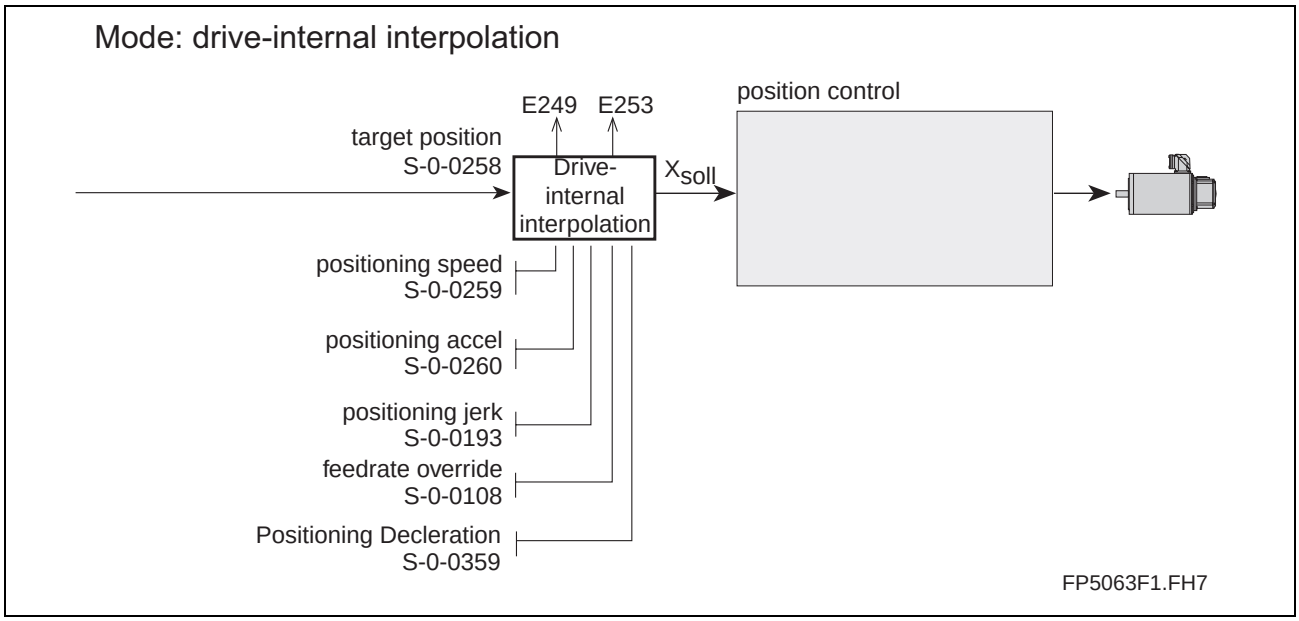



Fig. 8-13: Generating the position command value with drive-internal interpolation

**S-0-0393, Command value mode**

Via bit0 and bit1 in parameter **S-0-0393, Command value mode** it is possible to fix both processing and effectiveness of **S-0-0258, Target position** with modulo processing.

**Structure of parameter:**

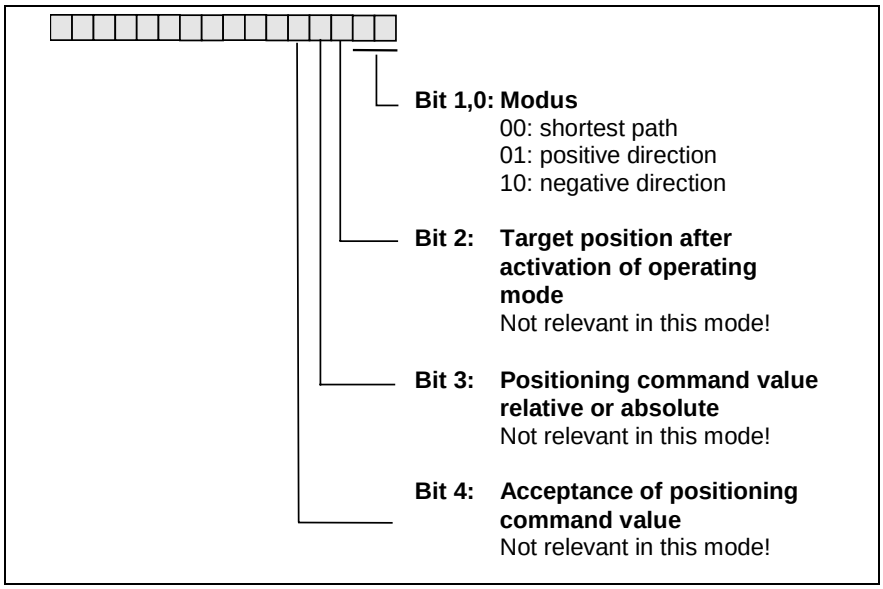

Bit 1,0: Modus
00: shortest path
01: positive direction
10: negative direction
Bit 2: Target position after activation of operating mode
Not relevant in this mode!
Bit 3: Positioning command value relative or absolute
Not relevant in this mode!
Bit 4: Acceptance of positioning command value
Not relevant in this mode!

Fig. 8-14: Structure of parameter S-0-0393, Command value mode

For further information, also see parameter description **S-0-0393, Command value mode**.

## Monitoring and Diagnosing

**The diagnosis with activated operating is one of the following:**

- **A106 Drive controlled interpolation, encoder 1**
- **A107 Drive controlled interpolation, encoder 2**
- **A108 Drive controlled interpolation, lagless, encoder 1**
- **A109 Drive controlled interpolation, lagless, encoder 2**

The following checks are executed:

**E253 Target position out of travel range**

- If axis limit value monitoring is activated ( Bit 4 of **S-0-0055, Position Polarity Parameter** is set ) and the measurement system used for the operating mode has been homed, the parameter **S-0-0258, Target Position** is monitored for staying within the axis limit values (S-0-0049 and S-0-0050).
  If these are exceeded, the warning **E253 Target position out of travel zone** is generated.

  The prescribed target position will not be accepted.

**E247 Interpolation velocity = 0**

- If the positioning velocity specified in **S-0-0259, Positioning velocity** equals 0, then warning **E247 Interpolation velocity = 0** is generated. This warning is only generated if S-0-0259 is not cyclically transmitted via command communications (SERCOS, Profibus, ...) to the drive.

**E248 Interpolation acceleration = 0**

- If the positioning acceleration specified in **S-0-0260, Positioning acceleration** equals 0, then warning **E248 Interpolation acceleration = 0** is generated.

**E249 Positioning velocity >= S-0-0091**

- If the prescribed positioning velocity **S-0-0259, Positioning velocity** exceeds the maximum allowable limit value ( **S-0-0091, Bipolar Velocity Limit Value**), the warning **E249 Positioning velocity S-0-0259 > S-0-0091** will be generated.

  The drive will move at the velocity **S-0-0091, Bipolar Velocity Limit Value** to the new target position.

**E255 Feedrate override S-0-0108 = 0**

- If the factor affecting positioning velocity as set in **S-0-0108, Feedrate override** equals 0, then warning **E255 Feedrate-override S-0-0108 = 0** is generated.

**E264 Target position out of num. range**

- If a continuous relative positioning exceeds the internal illustration range for the position data, then warning **E264 Target position out of number range** is generated.

## Status messages

In parameters S-0-0013, class 3 diagnostics and S-0-0182, manufacturers class 3 diagnostics there are the following status messages for this mode:

- "target position reached", bit 12 of **S-0-0013, Class 3 Diagnostics**
- "In target position", bit 10 of **S-0-0182, Manufacturer Class 3 Diagnostics**
  (Is displayed on bit 4 of **P-0-4078, Fieldbus status word**)
- "IZP", bit 6 of **S-0-0182, Manufacturer Class 3 Diagnostics**

The following profile explains how the status messages work:

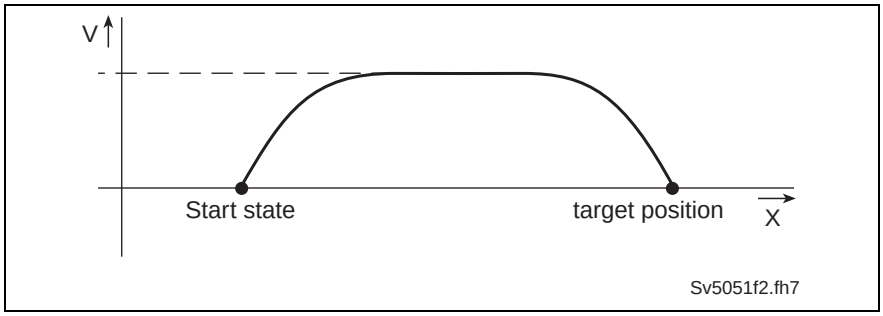



Fig. 8-15: Profile to explain how the interpolation status messages work

In this example, the drive is at the start position, when the new target position is given.

The following time diagram result:

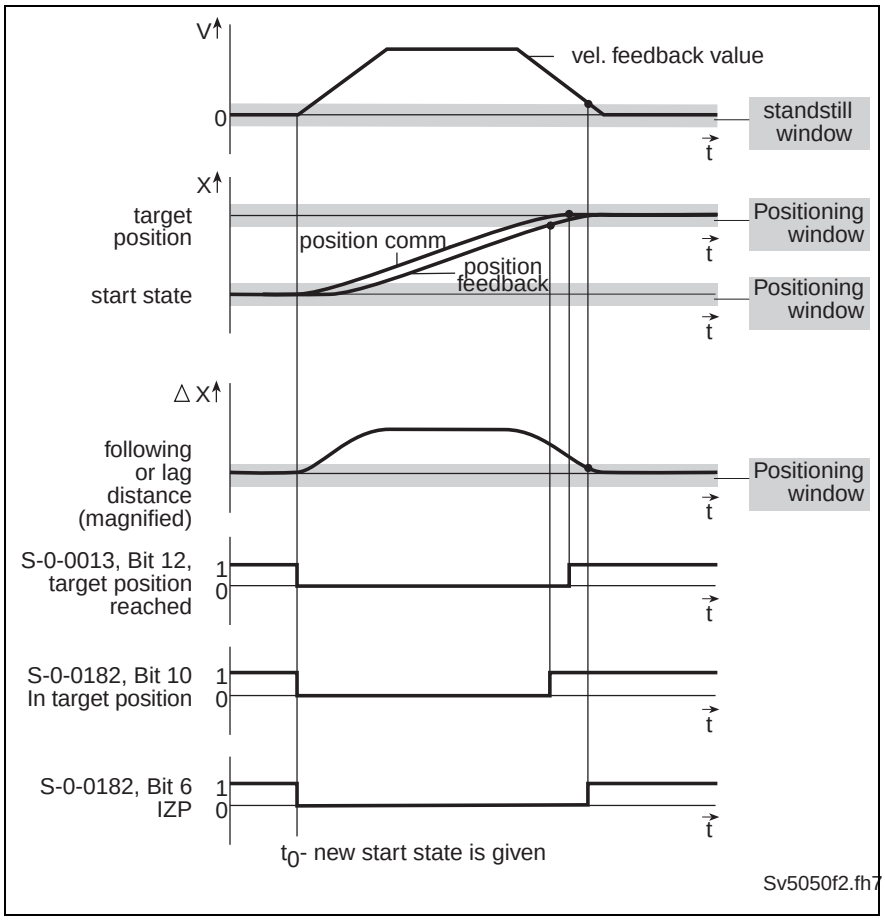



Fig. 8-16: Generating the status bit of the operating modes with drive-internal interpolation

# 8.7 Operating Mode: Drive Controlled Positioning

**Note:** Mode "Drive controlled positioning" can only be used in free configurable mode (profile selection P-0-4084 = 0xFFFE). Parameter **S-0-0282, Positioning command** is configured in this case in the real time channel to transmit absolute target position or travel path. The control and status bits needed for the function are in the fieldbus control and status words.

In "Drive controlled positioning" the drive receives a positioning command value (absolute or relative). The drive runs maintaining positioning velocity, accel and jerk to the specified target position.

## Pertinent Parameter

For the motion calculation the following are used:

- **S-0-0108, Feedrate override**
- **S-0-0193, Positioning Jerk**
- **S-0-0258, Target position**
- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0282, Positioning command**
- **S-0-0346, Positioning command latch**
- **S-0-0359, Positioning Deceleration**
- **S-0-0393, Command value mode**

For the status display the following parameter are used:

- **S-0-0419, Positioning command acknowledge**
- **S-0-0182, Manufacturer class 3 diagnostics**

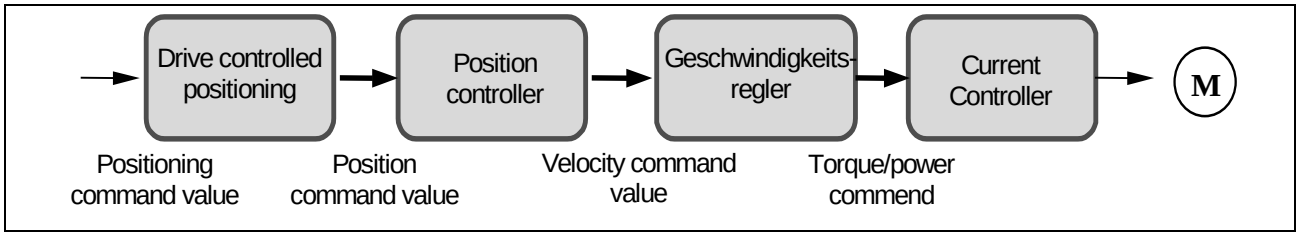



Fig. 8-17: Block diagram drive controlled positioning

## Functional Principle

Target position or travel path is specified in parameter **S-0-0282, Positioning command**. In bit 3 of parameter **S-0-0393, Command value mode** it is set whether positioning command value is relative or absolute.

**Absolute Positioning command value**
(S-0-0393, Bit 3=0)

A status change in parameter **S-0-0346, Positioning command latch** means positioning command value is directly accepted into parameter **S-0-0258, Target position**.

**Relative Positioning command value**
(S-0-0393, Bit 3=1)

A status change in parameter **S-0-0346, Positioning command latch** means positioning command value is added to parameter **S-0-0258, Target position**.

**Note:** Bit 0 of parameter **S-0-0346, Positioning command latch** is cyclically transmitted to fieldbus control word (Bit 0). This means it is not necessary to configure S-0-0346 in the real time channel (compare **P-0-4081, Real-time output object structure**).

**Note:** The target position can also be directly set in parameter **S-0-0258, Target position**. The specified value is always processed absolutely and is immediately given to the position command value generator, i.e., bits 3 and 4 of parameter **S-0-0393, Command value mode,** Parameter **S-0-0346, Positioning command latch** are not significant in this case.

The drive generates the target position to be run to and the needed position command value profile while maintaining all marginal conditions set in

- **S-0-0259, Positioning Velocity**
- **S-0-0260, Positioning Acceleration**
- **S-0-0359, Positioning Deceleration**
- **S-0-0193, Positioning Jerk**
- **S-0-0108, Feedrate override**

**Effective positioning velocity**

The maximum velocity achieved by the drive after an acceleration phase with the value set in **S-0-0260, Positioning Acceleration**.

The maximum velocity during a positioning procedure is the result of:

$$V_{max} = S-0-0259, \text{Positioning Acceleration} * \frac{S-0-0108, \text{ Feedrate override}}{100\%}$$

**Effective accel and decel**

The maximum delay is fixed in parameter **S-0-0359, Positioning Deceleration**.

If parameter **S-0-0359, Positioning Deceleration** equals zero, then the drive uses parameter **S-0-0260, Positioning Acceleration** for decel as well.

**CAUTION**

**Damage to property with wrong parametrization**

If the values for positioning decel and accel are zero, then the drive cannot brake. The set target is never reached or is overrun.

⇒ Always enter for positioning accel a value of > 0.

**Smoothing filter (or jerk filter)**

Accel and decel are smoothed using a jerk limit value and a PT1 filtering. This means that accel or decel do not become effective until after t= $5*T_R$.

The time constant $T_R$ of the smoothing filter (jerk filter) results from:

$$T_R = \frac{S-0-0260, \text{Positioning Acceleration}}{S-0-0193, \text{Positioning Jerk}}$$

bzw.

$$T_R = \frac{S-0-0359, \text{Positioning Deceleration}}{S-0-0193, \text{Positioning Jerk}}$$

**Note:** For the accel or decel procedure only one time constant, namely the biggest one in the above equation, is always used.

**S-0-0193, Positioning Jerk = 0** switches the smoothing filter off, the desired accel or decel is reached directly.

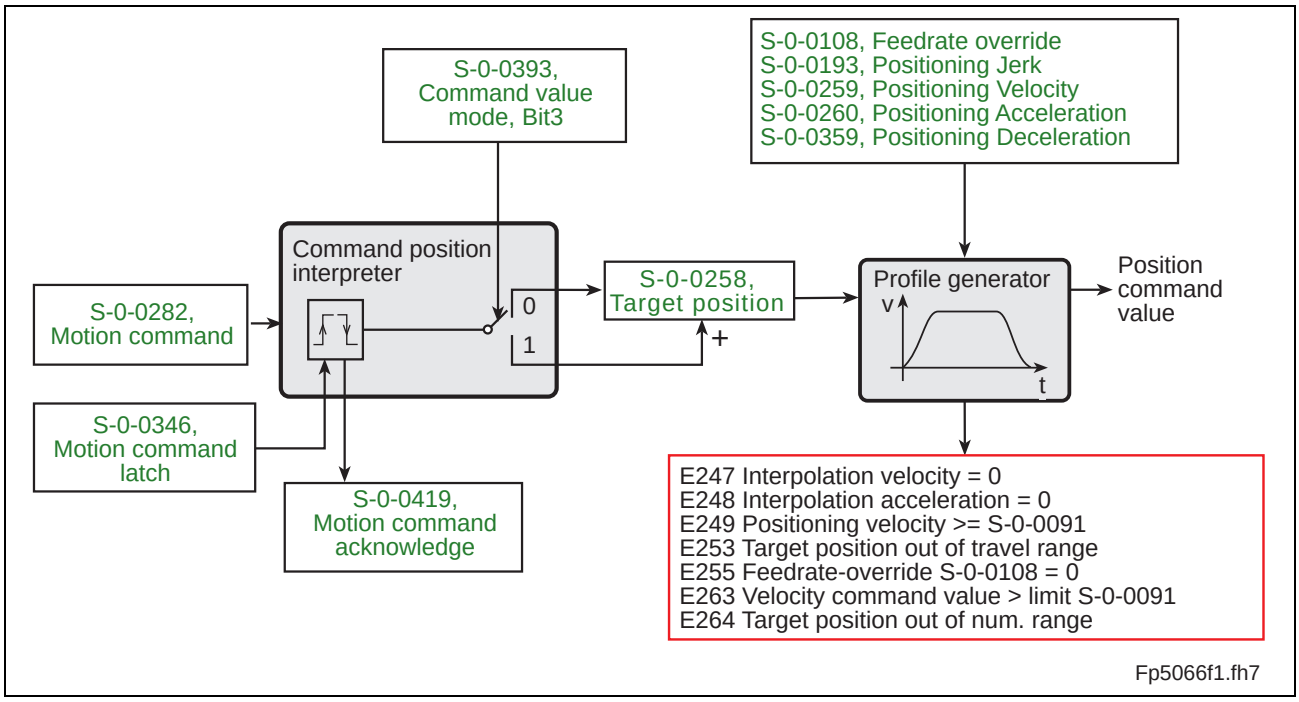



Fig. 8-18: Generating position command value

**S-0-0393, Command value mode**

Accepting and defining parameter **S-0-0282, Positioning command depends** on what is set in parameter **S-0-0393, Command value mode.**

**Structure of parameter:**

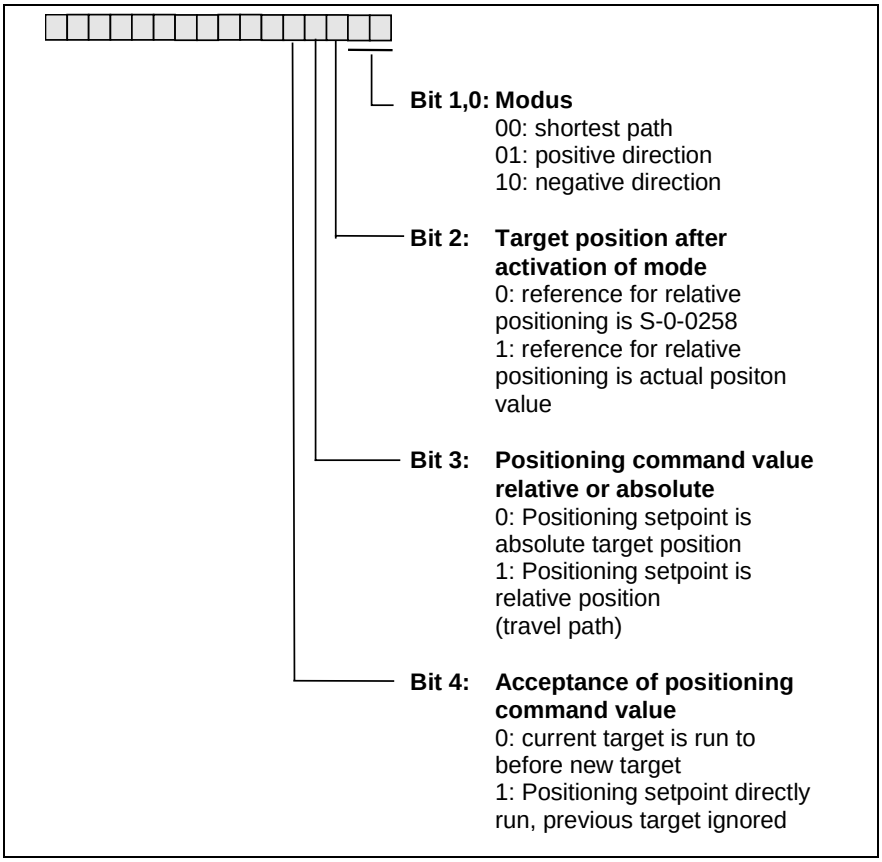

Bit 1,0: Modus
00: shortest path
01: positive direction
10: negative direction
Bit 2: Target position after activation of mode
0: reference for relative positioning is S-0-0258
1: reference for relative positioning is actual positon value
Bit 3: Positioning command value relative or absolute
0: Positioning setpoint is absolute target position
1: Positioning setpoint is relative position (travel path)
Bit 4: Acceptance of positioning command value
0: current target is run to before new target
1: Positioning setpoint directly run, previous target ignored

Fig. 8-19: Structure of parameter S-0-0393, Command value mode

For more information, see parameter description **S-0-0393, Command value mode**.

# Acknowledging command value latch

**S-0-0419, Positioning command value-acknowledge**

Acknowledging acceptance of S-0-0282 supports the ability of control to make information available as to whether the previous positioning command value was accepted by the drive or not.

**Note:** Bit 0 of parameter **S-0-0419, Positioning command acknowledge** is cyclically transmitted in fieldbus status word. This means no configuration is needed in the real time channel.

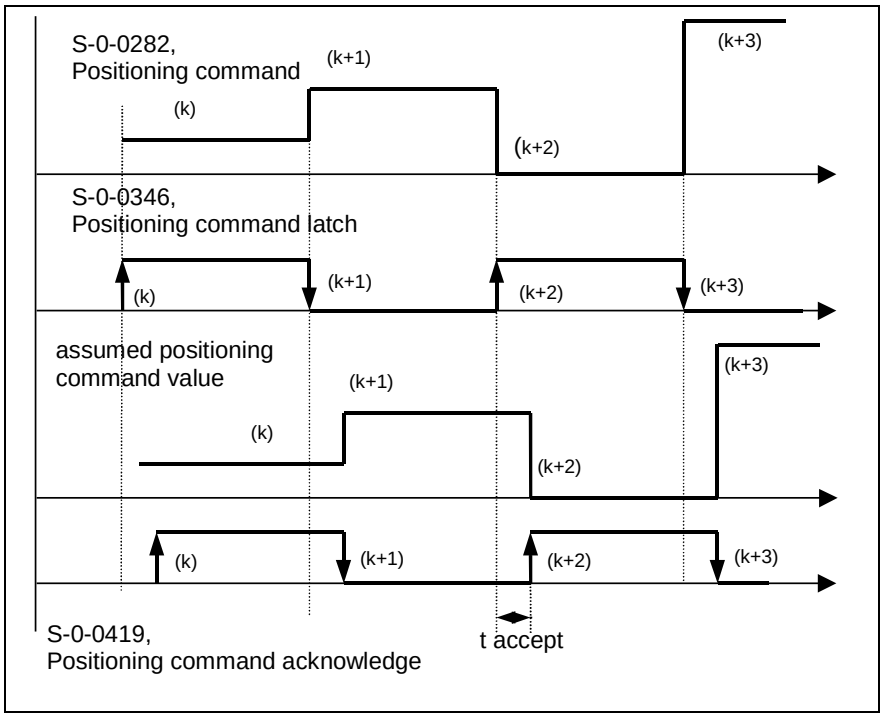



Fig. 8-20: Positioning command value acceptance and acknowledge

Time $t_{accept}$ (see illustration above) defines the time between status changes and acceptance bits from the control and the receipt of acknowledge in the control. The time is made up of effective transmission time and command and actual values and thus depends on the configuration of the interface to the control (e.g., SERCOS/Fieldbus-Timing-Parameter).

**Note:** If mode "Drive controlled positioning" is not yet active, then the acknowledgement of acceptance of the new positioning command value does not take place.

**Acknowledge if parameter S-0-0393, setpoint mode, Bit 4 = 0**

By setting bit 4 to "0" in parameter **S-0-0393, Command value mode** it is ensured that a positioning command value specified once will always be run to.

The acknowledgement of acceptance takes place when the new positioning command value is accepted into the intermediate memory in parameter **S-0-0258, Target position** and thus in the position command value generator.

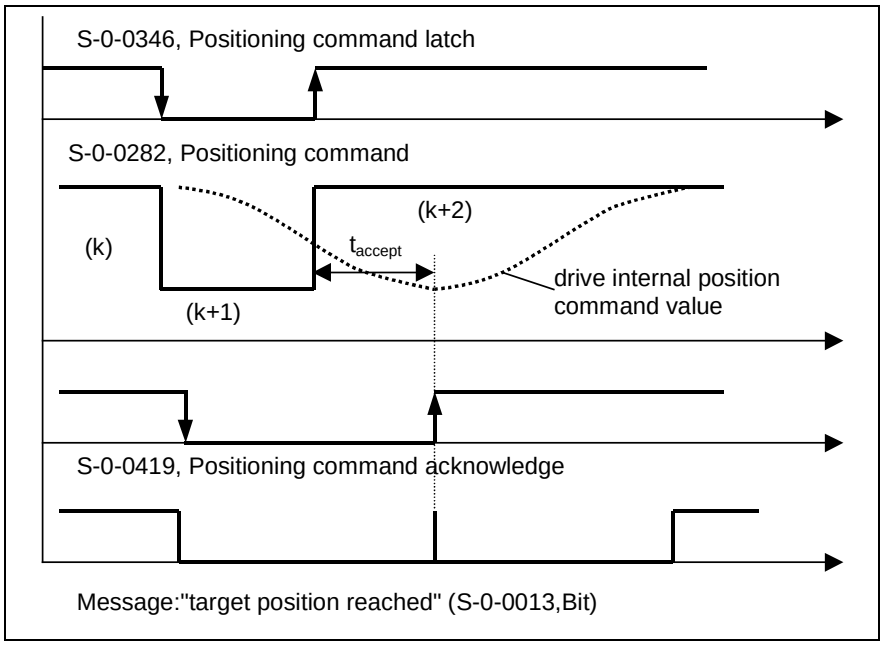



Fig. 8-21: Acknowledge acceptance of positioning command value in mode "running of positioning command value (k+2)"

**Acknowledge with error when positioning setpoint overrun**

If in mode "Running to positioning command value" the attempt is made to set a new positioning command value by toggeling parameter **S-0-0346, Positioning command latch** even though the previous positioning command value (k+1) has not yet been accepted (as the previous one was not run to yet), then error **F250 Overflow of target position preset memory** is generated.

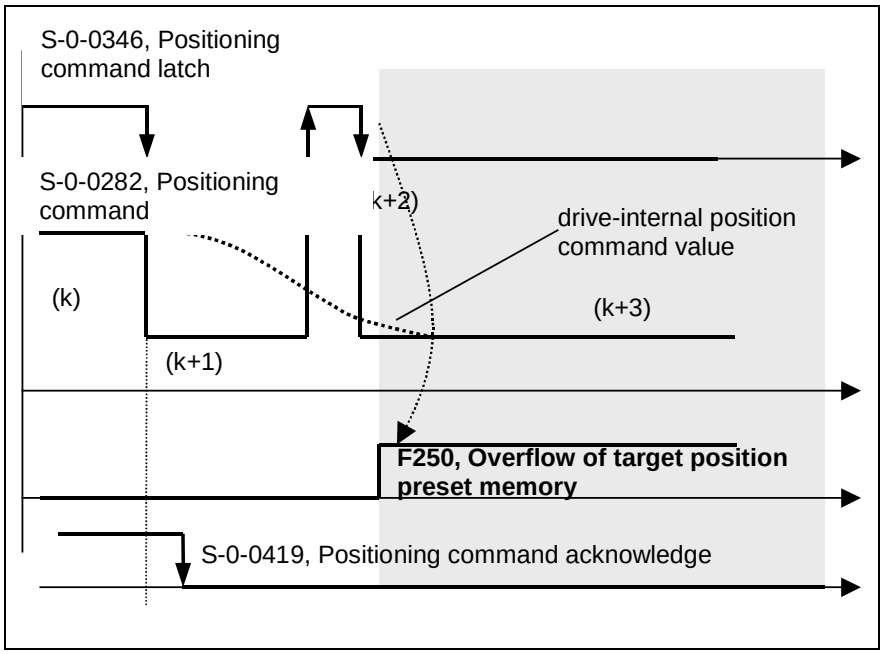



Fig. 8-22: Acknowledge error overrun in positioning command value

## Monitoring and Diagnoses

**Diagnoses with active mode is one of the following:**

- **A106 Drive controlled interpolation, encoder 1**
- **A107 Drive controlled interpolation, encoder 2**
- **A108 Drive controlled interpolation, lagless, encoder 1**
- **A109 Drive controlled interpolation, lagless, encoder 2**

The following tests are conducted:

**E253 target positioning outside of travel range**

- If monitoring of position limit value is active (Bit 4 of **S-0-0055, Position polarities** is set) and the measuring system of the mode is in reference, then the parameter **S-0-0258, Target position** is checked to maintain position limit value (S-0-0049 or S-0-0050). If it overruns it, then warning **E253 Target position out of travel range** is generated.

  The prescribed target position will not be accepted.

**E247 Interpolation velocity = 0**

- If specified positioning velocity in **S-0-0259, Positioning Velocity** is "0", then warning **E247 Interpolation velocity = 0** is generated. It is only generated if S-0-0259 is not cyclically transmitted via command communication (SERCOS, Profibus, ...) to the drive.

**E248 Interpolation accel = 0**

- If specified positioning velocity in **S-0-0260, Positioning Acceleration** is "0", then warning **E248 Interpolation acceleration = 0** is generated.

**E249 Positioning velocity > S-0 0091**

- If the specified positioning velocity **S-0-0259, Positioning Velocity exceeds maximum limit value** (**S-0-0091, Bipolar velocity limit value**) then warning **E249 Positioning velocity >= S-0-0091** is generated.

  The drive runs at velocity **S-0-0091, Bipolar velocity limit value** to the new target position.

**E255 Feedrate-Override S-0-0108 = 0**

- If the factor of positioning velocity **S-0-0108, Feedrate override** is "0", then warning **E255 Feedrate-override S-0-0108 = 0** is generated.

**E264 target position cannot be illustrated**

- If continuous relative positioning means that the internal range of the position data is exceeded, then warning **E264 Target position out of num. range** is generated.

## Status messages

In parameters **S-0-0013, Class 3 diagnostics** and **S-0-0182, Manufacturer class 3 diagnostics** there are the following status messages for these modes:

- "Target position reached, bit 12 of **S-0-0013, Class 3 diagnostics**
- "In target position", bit 10 of **S-0-0182, Manufacturer class 3 diagnostics**
  (Is shown on bit 4 of **P-0-4078, Fieldbus status word**)
- "IZP", Bit 6 of **S-0-0182, Manufacturer class 3 diagnostics**

The following profile explains how the status messages work:

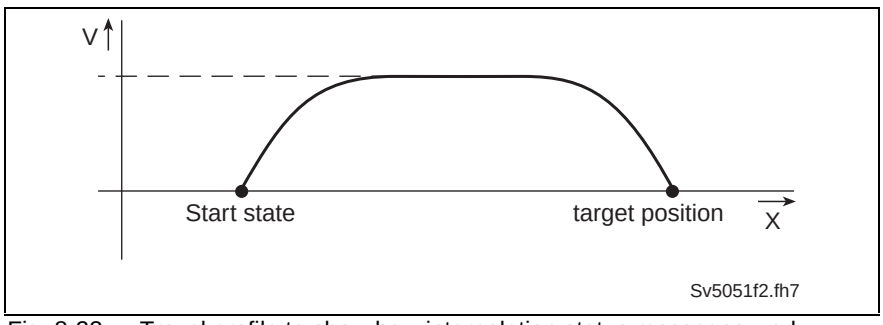



Fig. 8-23: Travel profile to show how interpolation status messages work

In this example, the drive is in start position when the new target position is specified.

This results in the following time diagram:

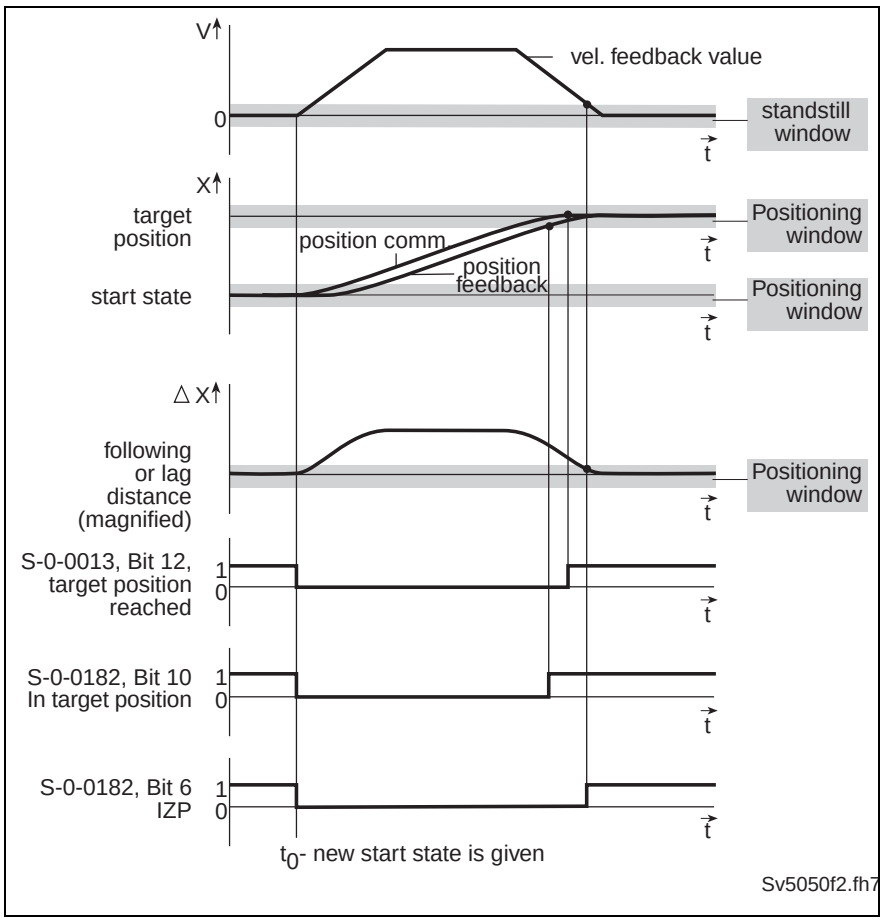



Fig. 8-24: Generating status bits of operating mode with drive-controlled positioning

## 8.8 Positioning Block Mode

**Note:** With the profile types:
-P-0-4084, Operation mode selection code = 0xFF80 or
-P-0-4084, Operation mode selection code = 0xFF81 or
-P-0-4084, Operation mode selection code = 0xFF82
the operating mode "positioning block mode" is automatically internally set!

Sixty-four (64) positioning blocks that have been pre-programmed can be run with this mode. The drive runs position control to a target position, while maintaining speed, acceleration, deceleration and jerk limits as defined for each block.

The positioning blocks are actuated by the block selection.

Following block processing permits execution of several positioning blocks processed in direct sequence without having to re-issue a start signal each time.

Typical applications are positioning processes which cover long distances at high speeds (rapid traverse) and then position at end position at low speeds without any intermediate stops.

- Taking up or putting down transport goods by robots.
- Execution of joining processes in assembly facilities

A following block chain is made up of a start block and one or more following blocks. The start block is selected and activated in the usual manner. The transition to a following block, however, can vary.

**Note:** **Following block mode** is possible with absolute and relative positioning blocks. The distance remaining is stored. The final block of a chain is not defined as a following block. This identifies the end of the chain.

## Pertinent Parameters

- **P-0-4006, Process block target position**
- **P-0-4007, Process block velocity**
- **P-0-4008, Process block acceleration**
- **P-0-4009, Process block jerk**
- **P-0-4019, Process block mode**
- **P-0-4026, Process block selection**
- **P-0-4051, Process block acquittance**
- **P-0-4052, Positioning block, last accepted**
- **P-0-4057, Positioning block, input linked blocks**
- **P-0-4060, Process block control word**
- **P-0-4063, Process block deceleration**
- **S-0-0346, Set-up flag for relative command values**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0259, Positioning Velocity**

**Note:** S-0-0259 is used in positioning block mode to reduce positioning velocity. (See also **P-4060, Process block control word**).

## How it works

**Positioning block elements**

A positioning block is defined with:

- **P-0-4006, Process block target position,**
- **P-0-4007, Process block velocity,**
- **P-0-4008, Process block acceleration,**
- **P-0-4009, Process block jerk,**
- **P-0-4019, Process block mode.**
- **P-0-4063, Process block deceleration**

and fixes how the target position is to be processed (**absolute**, **relative**).

**Note:** Each parameter has 64 elements, whereby the elements of the same number write this number into the travel profile of the positioning block.

The drive reaches the relevant positioning block velocity after an acceleration phase with the relevant **P-0-4008, Process block acceleration.**

The effective velocity during a positioning procedure is computed as follows:

$$Vmax = P\text{-}0\text{-}4007 * S\text{-}0\text{-}0108 / 100\%$$

Vmax: velocity
P-0-4007, Process block velocity
S-0-0108, Feedrate override

Fig. 8-25: Effective velocity during a positioning procedure

The maximum decel is specified by parameter **P-0-4063, Process block deceleration**.

**Effective accel and delay**

If parameter **P-0-4063, Process block deceleration** equals zero, then the drive uses parameter **P-0-4008, Process block acceleration** to decel**.**

**CAUTION**

**Property damage !**

If the accel value is always equal to zero, then the drive can no longer brake. The specified target is not reached or overrun.

⇒ Accel value > 0 set

Accel and decel are smoothed with the specification of a jerk limit value using a PT1 filter. The accel or decel is thus reached after about five times the time constant.

The time constant of this smoothing filter is computed:

$$T = P\text{-}0\text{-}4008 / P\text{-}0\text{-}4009$$

or

$$T = P\text{-}0\text{-}4063 / P\text{-}0\text{-}4009$$

P-0-4008, Process block acceleration
P-0-4009, Process block jerk
P-0-4063, Process block deceleration

Fig. 8-26: Determining the time constant

The same time constant is used for both accel and decel. The higher time constant of the above relationship is used.

If parameter **P-0-4009, Process block jerk** is equal to zero, then the smoothing filter is off, either accel or decel is being reached.

**Positioning block control word**

With parameter **P-0-4060, Process block control word** the positioning speed can be limited to the value set in parameter **S-0-0259, Positioning Velocity**.

**Position return message**

If a positioning block is completed, then bit 12 "End position reached" is set in parameter

**S-0-0182, Manufacturer class 3 diagnostics**

(→ |target position-actual position value < positioning window).

**Interrupting a positioning block**

An interruption can be the result of

- removal of the drive enable
- activation of drive halt.

# Activating Positioning Blocks

"Positioning block mode" must be entered as the main mode. By activating drive enable and setting drive halt =1 the drive is in primary mode of operation.

A positioning block is started by

- Status change of bit 0 of the parameter **S-0-0346**, **Setup flag for relative command values**

If the drive is working in “free-configurable mode" (**P-0-4084, Profile type** = 0xfffe), then the command value is transmitted in the fieldbus control word (P-0-4077, bit 0 equals S-0-0346 bit 0).

If profile type "I/O mode" (**P-0-4084, Profile type** = 0xff80) has been set in the drive, then a positioning block starts by setting the start signal (**P-0-4077, Fieldbus control word,** bit 1) or the "strobe signal" (**P-0-4077, Fieldbus control word**, bit 3).

---

**Note:** As long as the parameter is not toggled, the drive will remain on the actual position or brought to a position controlled standstill.

---

**Block selection**

In positioning block mode, a positioning block is selected

- by writing into **P-0-4026, Process block selection**
- or with **Bit8 - Bit 13** in **P-0-4077, Fieldbus control word** in **IO mode.**

# Positioning Block Modes

Parameter **P-0-4019, Process block mode** is used to set the manner in which the target position is processed in parameter **P-0-4006, Process block target position**.

Possible positioning block modes:

- **Absolute Positioning**
- **Relative Positioning**
- **Relative Positioning with residual path memory**
- **Infinite travel in positive / negative direction**
- **Following block processing**

---

**Note:** The control of fieldbus drive does not work over parameter **S-0-0134, Master control word**, but rather via the profile-dependent bits in **P-0-4077, Fieldbus control word**.

---

## Absolute Positioning

**Prerequisite:** Parameter **P-0-4019, Process block mode** = 1

In an absolute positioning block, the target position is a fixed (absolute) position within the machine co-ordinate system.

**Prerequisites for the execution of absolute positioning blocks:**

- The drive must be referenced.
- The travel range can be limited with position limit value. Absolute positioning blocks are only executed if the target position lies within the allowable travel range.

**Example** Absolute positioning with target position = 700

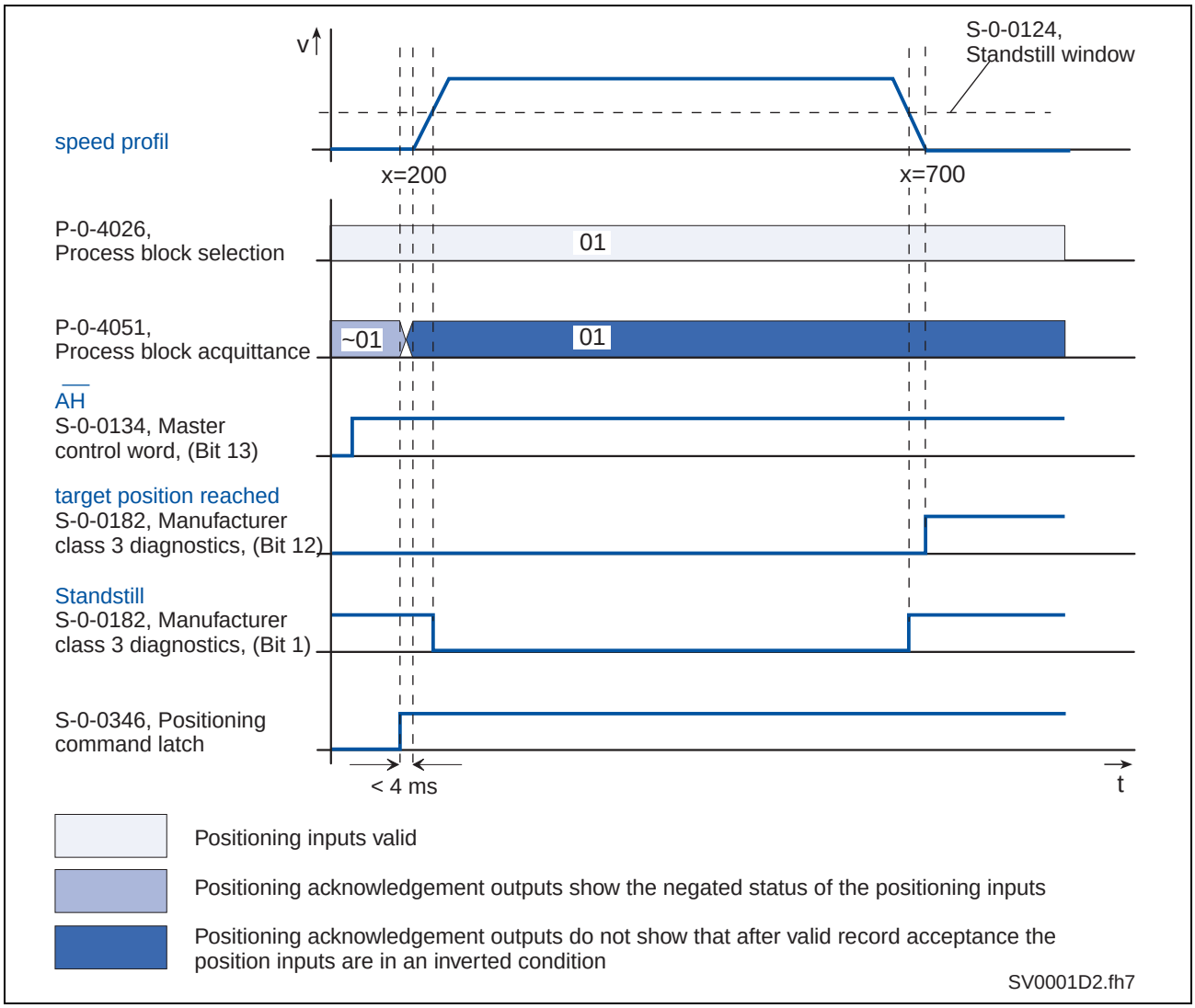



Fig. 8-27: Absolute positioning block

## Relative positioning

**Prerequisite:** Parameter **P-0-4019, Process block mode** = 2

Relative positioning blocks are executed if the drive has not been referenced.

**Reference position**

In relative positioning blocks without residual path storage, the target position in the positioning blocks are added to the **current position.**

**Residual path**

If positioning blocks are interrupted, then a part of a path to the target position remains. This remaining distance is the residual path.

**Chain dimensional reference**

By sequencing relative positioning blocks it is possible to position with chain dimensional reference. If a relative block is interrupted **without residual** path storage, then this chain reference is **lost**.

If the positioning block is completed, i.e., the drive reaches target position and message "end position reached" is activated, then positioning is possible without the loss of the chain reference.

**Note:** If infinite positioning in either a forward or backward direction is achieved by sequencing relative positioning blocks (transport belt), then the position data must be scaled in modulo format . (Modulo value = transport belt length or modulo value = 2 times the maximum travel distance.)

**Example** Relative positioning without residual path storage with target position = 700 (current position = 200).

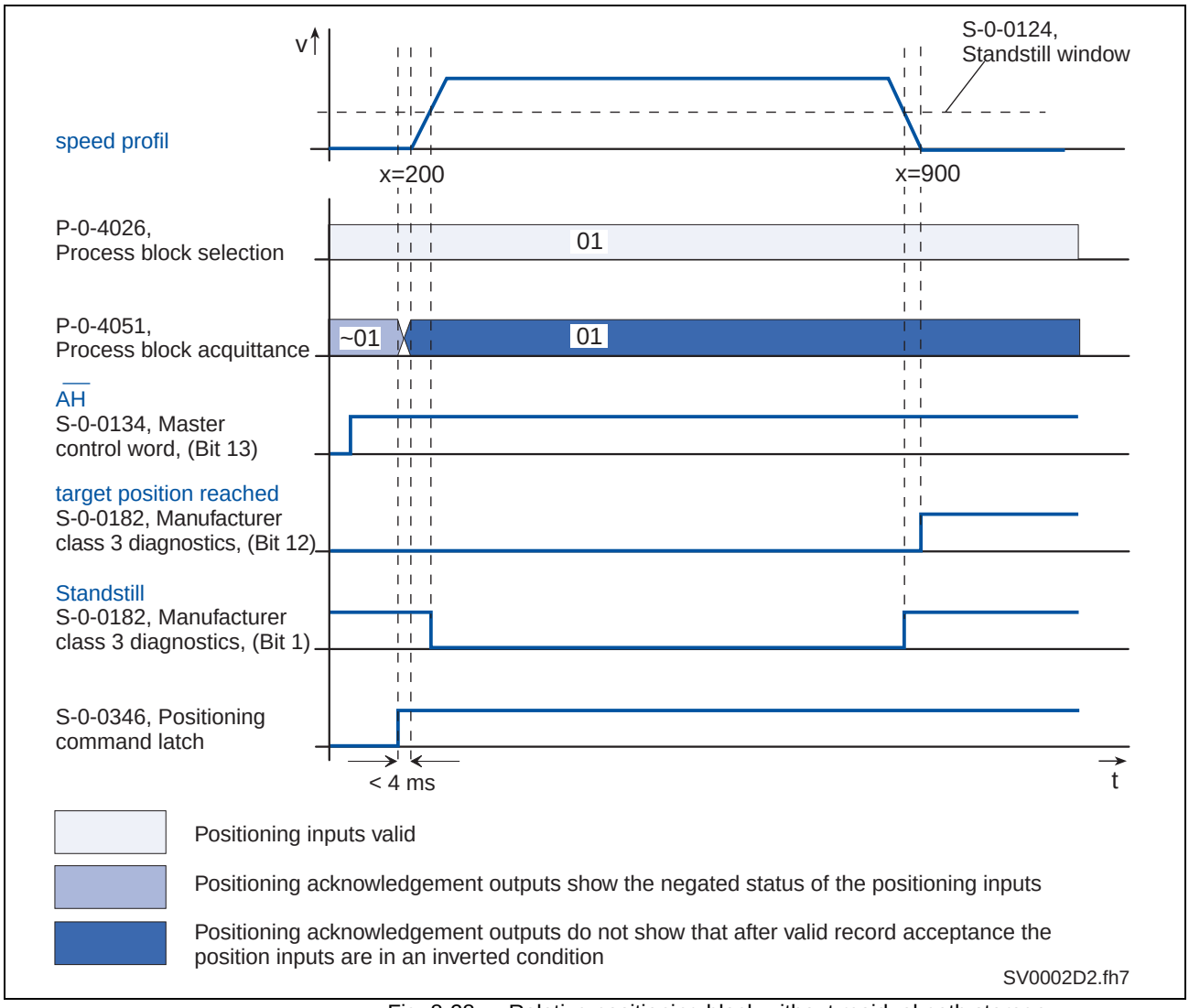



Fig. 8-28: Relative positioning block without residual path storage

**Example** Relative positioning without residual path storage with target position = 700 (current position = 200). Terminate and start a relative positioning block without residual path storage again.

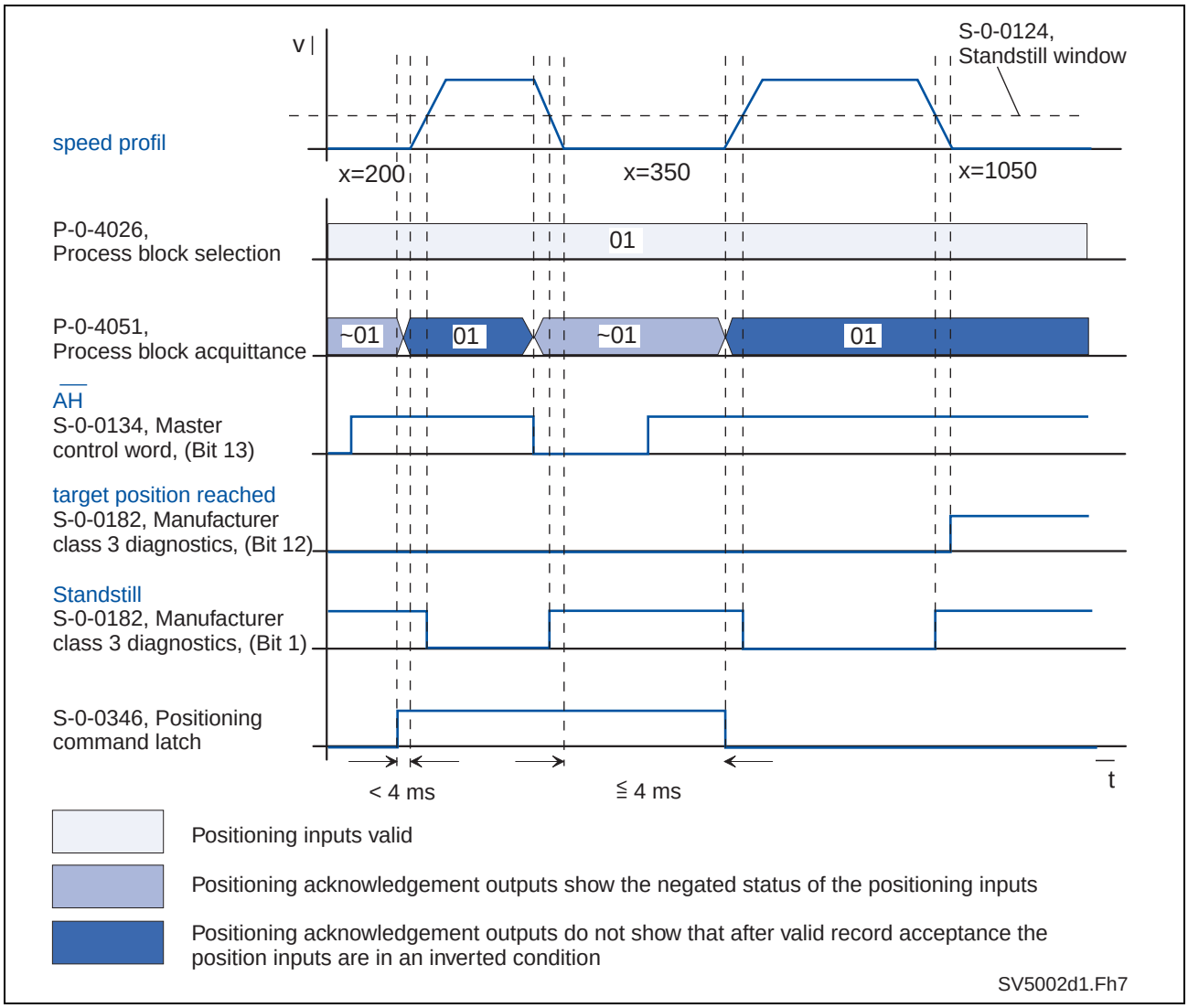



Fig. 8-29: Terminating a relative positioning block without residual path storage

## Relative positioning with residual path storage

**Prerequisite**

Parameter **P-0-4019, Process block mode** = 102h

Relative positioning blocks with residual path storage are also executed if the drive is not referenced.

In a relative positioning block with residual path storage, the target position is a relative path which relates to the target position which last generated the message "end position reached".

**Chain dimensional reference**

By sequencing relative positioning blocks it is possible to position with chain dimensional reference. If a relative block is interrupted **with residual** path storage, then this chain reference is **retained**.

**Note:** If a second positioning block is started while such a positioning block is being executed, then the remainder of the path is discarded. If this is a new block, a relative positioning block with residual path memory, then the target position is related to the current actual position as if it were a relative path.

**Note:** The rest of the path is discarded once a different positioning block is started.

**Example** Relative positioning with residual path storage with target position = 700 without interruption (message: "End position reached" with position = 200).

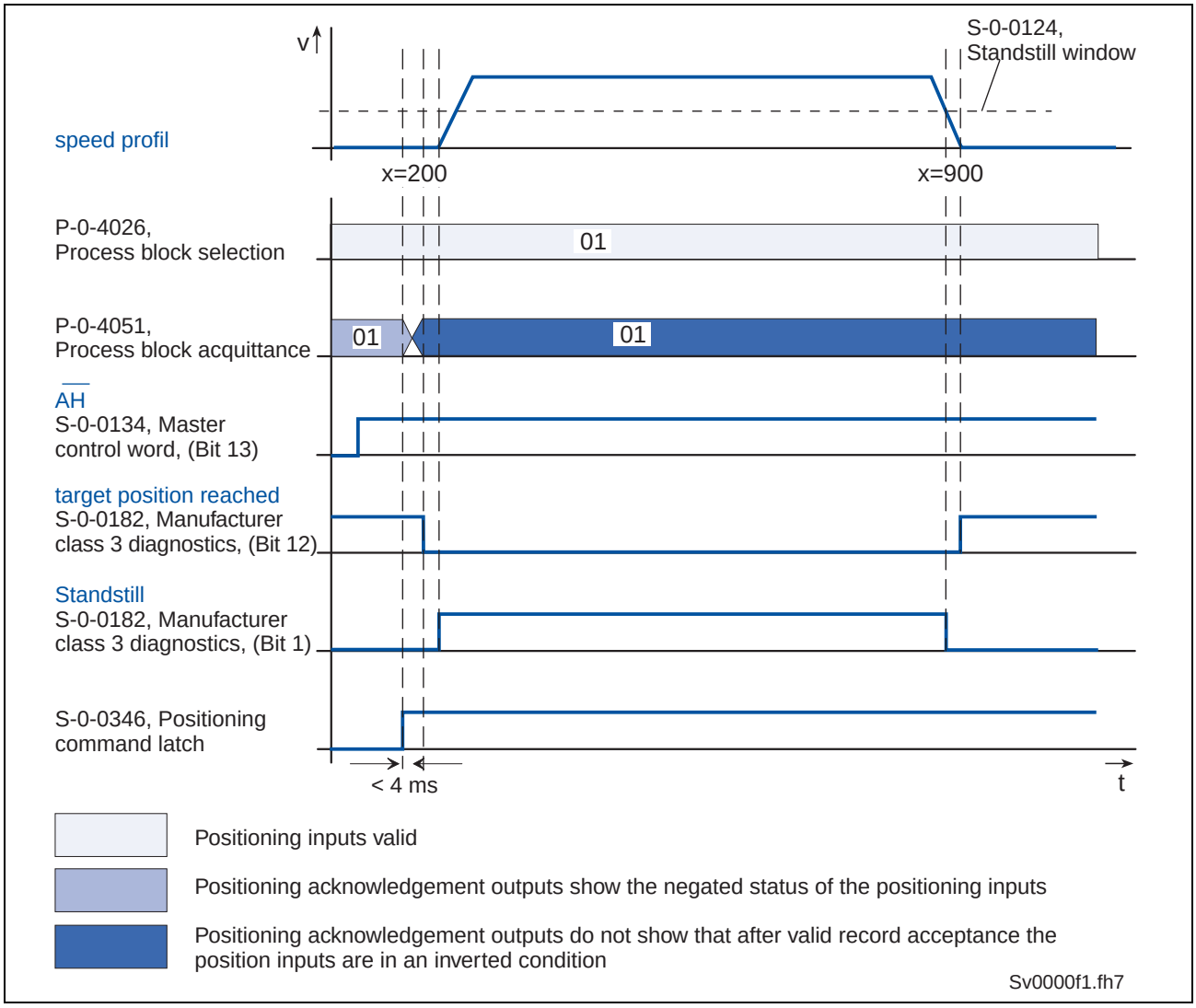



Fig. 8-30: Relative positioning block with residual path storage

**Relative positioning block with residual path storage after activating drive enable**

**Reference position** The **last "End position reached" message** is used as reference position.

**Note:** The chain reference dimension is guaranteed.

**Example** An interrupted relative positioning block with residual path storage after active drive enable with target position = 600.

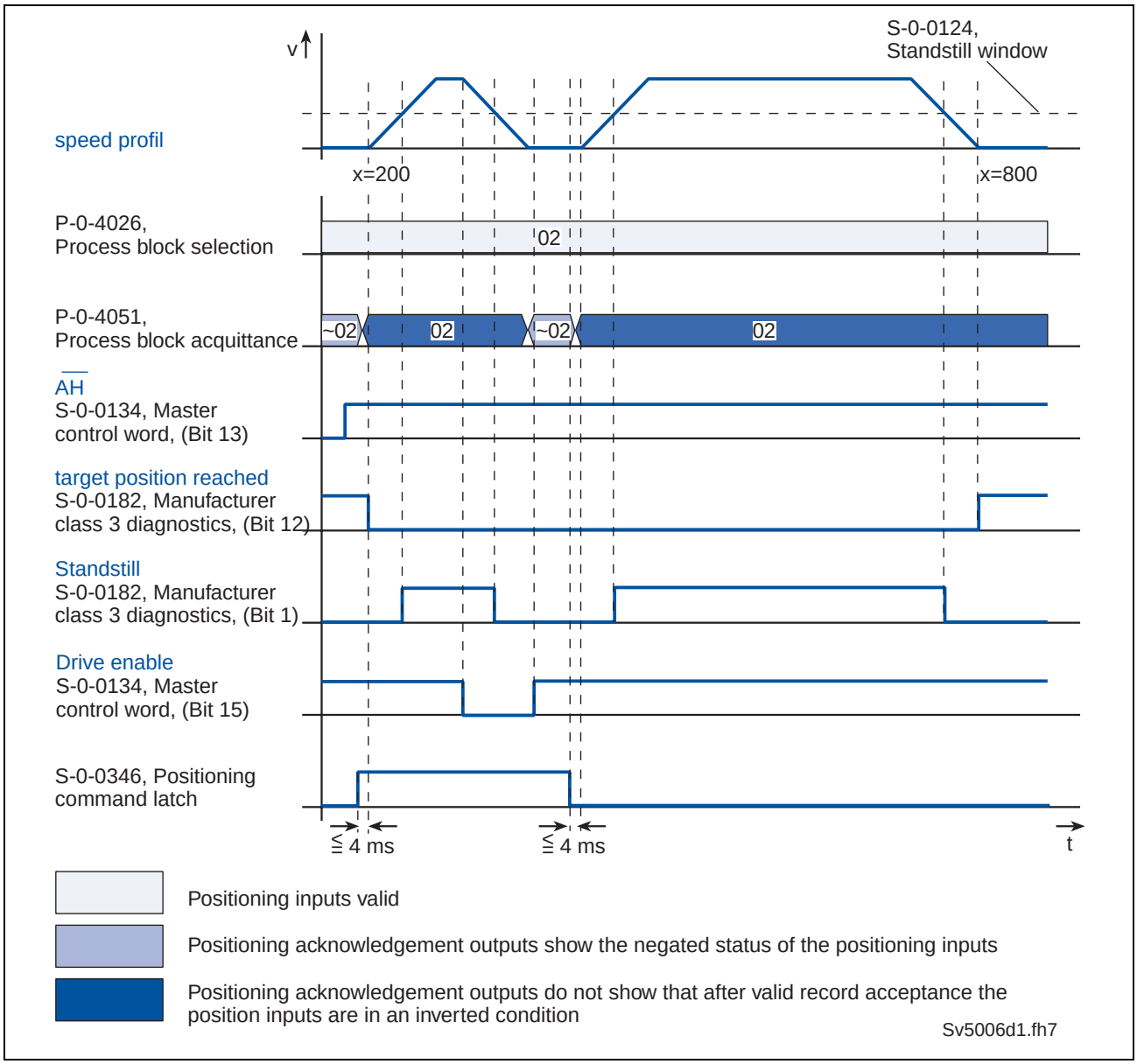



Fig. 8-31: Relative positioning block with residual path storage after activating the drive enable

**Relative positioning block with residual path storage after interrupting with jog mode**

**Example** Interrupted relative positioning block **with** residual path storage after jogging with target position = 600 **without overrunning the target position** while jogging.

**Reference position** The **last "End position reached" message** is used as reference position.

**Behavior** The stretch jogged between the **interruption** and **restart** of the positioning block is taken into account. The drive continues to run to the already computed target position.

**Note:** The chain dimensional reference is guaranteed.

**Example** Interrupted relative positioning block **with** residual path storage after jogging with target position = 600 **with overrunning the target position** while jogging.

**Behavior** The drive runs back to the target position set prior to the interruption.

**Note:** The chain dimensional reference is guaranteed.

**Reference position** The **last "End position reached" message** is used as reference position.

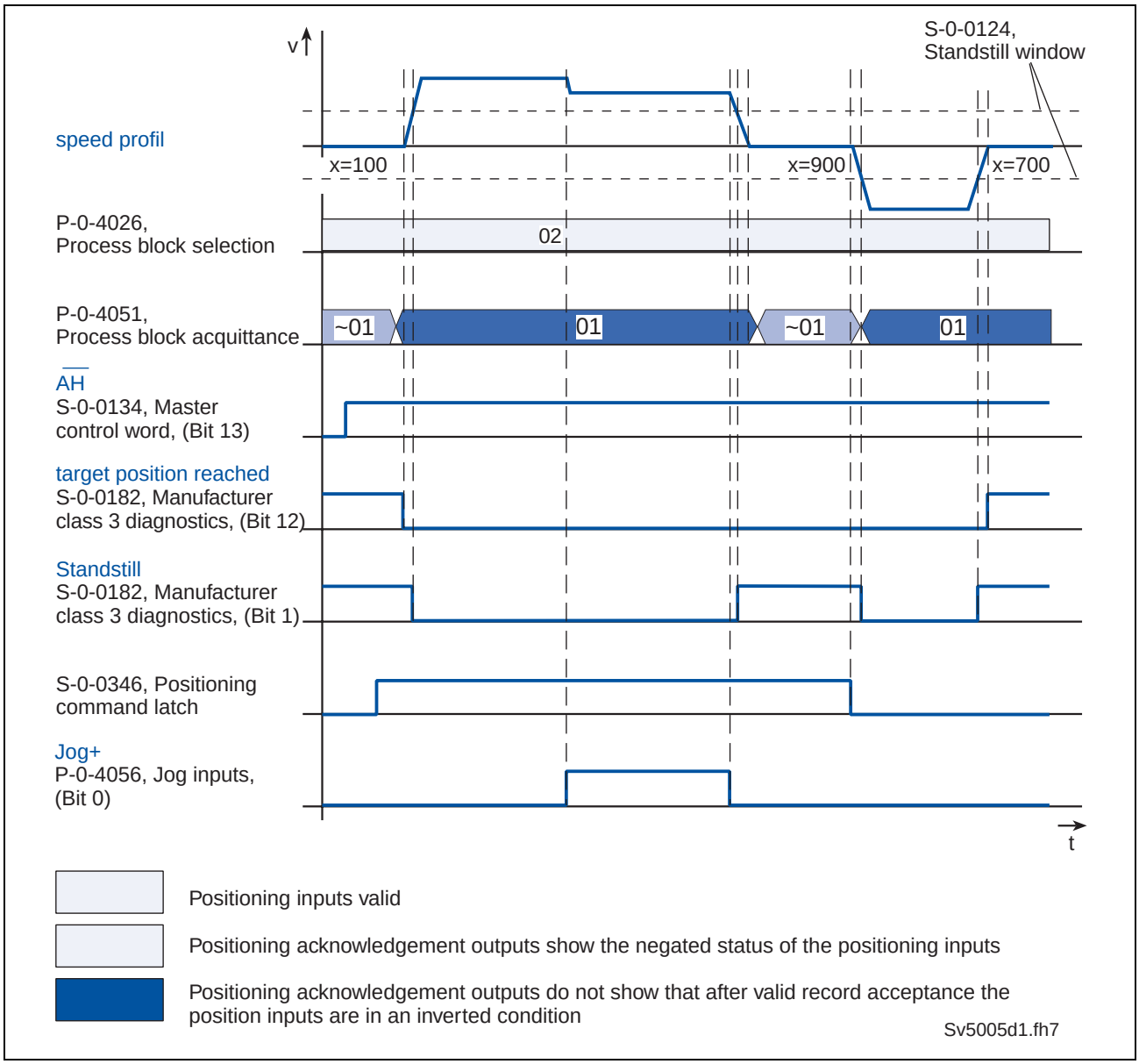



Fig. 8-32: Relative positioning block with residual path storage after jogging

**Relative positioning block with residual path storage after switching drive controller control voltage on and off**

If an **absolute encoder** is used then it is possible that the chain reference is retained after switching control voltage on and off. The previously computed target position is stored at power shutdown. The rest of the distance is travelled after the interrupted relative positioning block with residual path storage is activated.

**Behavior** If a **single turn encoder** is used, then the remaining path is discarded and added to the actual position.

**Reference position** The **last "End position reached" message** is used as reference position.

**Note:** If a positioning block is not accepted then the drive behaves as if it had never been started.

## Infinite running in a positive / negative direction

If an axis is to be run with defined speed, acceleration and jerk without a specific target position, then the travel block mode: **"Travelling in a positive direction"** or **"Travelling in a negative direction"** must be specified. The drive runs in the set direction until the start signal is reset or the position limit value or the travel range limit switch is reached.

The set target position is not used in this positioning mode.

Parameter **P-0-4019, Process block mode** =

- 4h travel in positive direction
- 8 h travel in negative direction

See also section: "Operating Mode: Jogging"

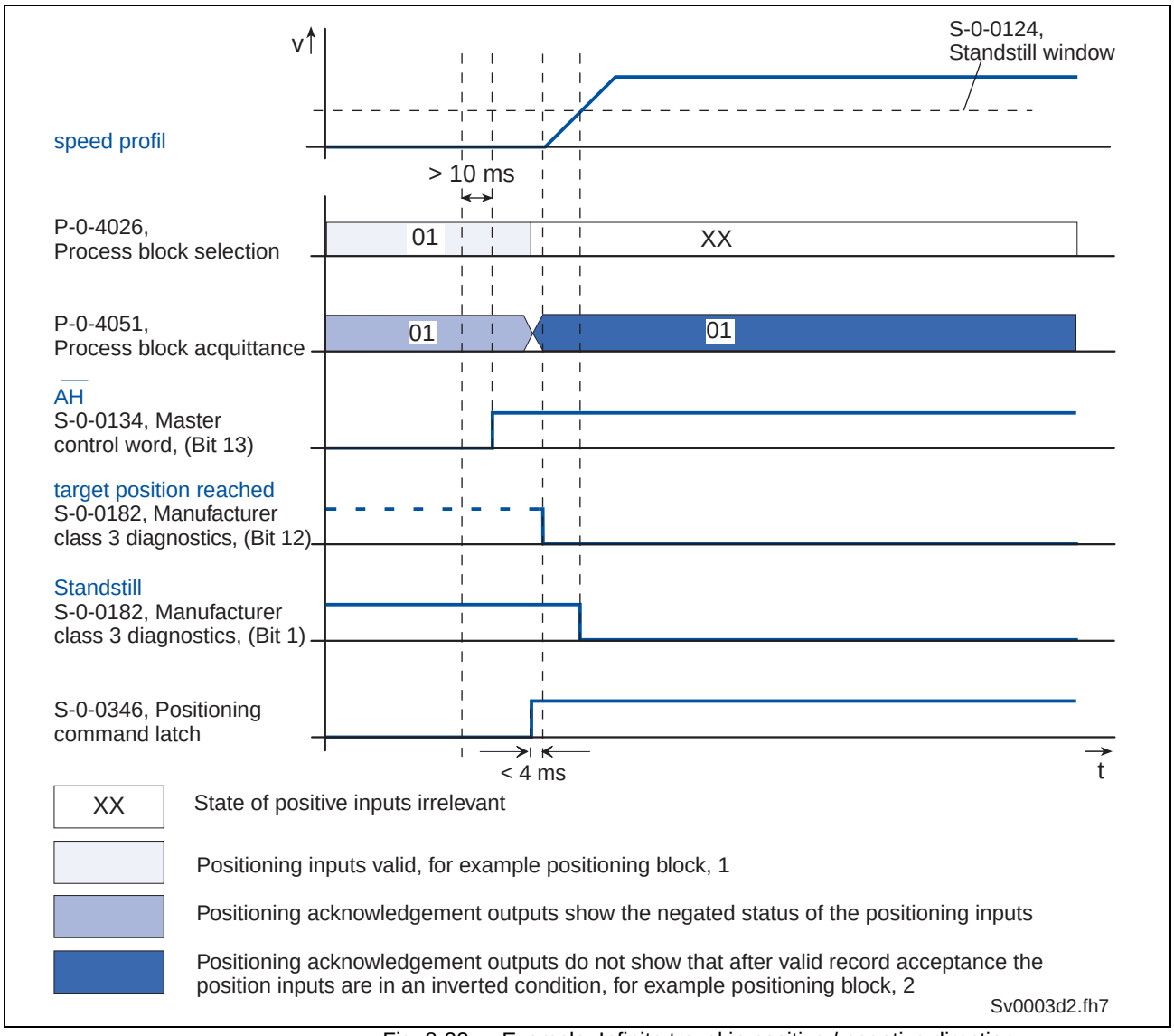



Fig. 8-33: Example: Infinite travel in positive / negative direction

## Following block processing

**Selecting and activating a following block**

Selecting and activating a block with following block is performed in the usual manner. The following block is that block with the next highest block number. A following block can also have a following block so that after a start block up to 63 following blocks can be set. The potential following block of the block with number 63 is block 0.

**Conditions to continue in following block mode**

There are **two possibilities** for continuing block mode. These are also broken down into:

**1) Position-dependent continue block mode**

With position-dependent continue block mode, the following block is switched into at the target position of the start block.

There are **three different** types of block transitions:

**a) Block transition at old positioning speed (Mode 1)**

P-0-4019, Process block mode = 11h: absolute block with following block

P-0-4019, Process block mode = 12h: relative block with following block

P-0-4019, Process block mode = 14h: infinite block in positive direction with following block

P-0-4019, Process block mode = 18h : infinite block in negative direction with following block

In this mode, the target position of the start block is run through at the speed of the start block and then switched to the positioning speed of the following block.

**Definition**

With relative and absolute blocks with sequential processing, the drive runs in the direction of the target position. As soon as the **target position is exceeded**, it switches to the **next block n+1.** With infinite blocks, the drive runs positive or negative. As soon as the **target position is exceeded**, the drive switches to **next positioning block n+1**. (**"n"** represents the block currently in process).

**Note:** If the target position is not in the travel direction, then the target position is nonetheless run to. Thus the drive always reaches the switching position.

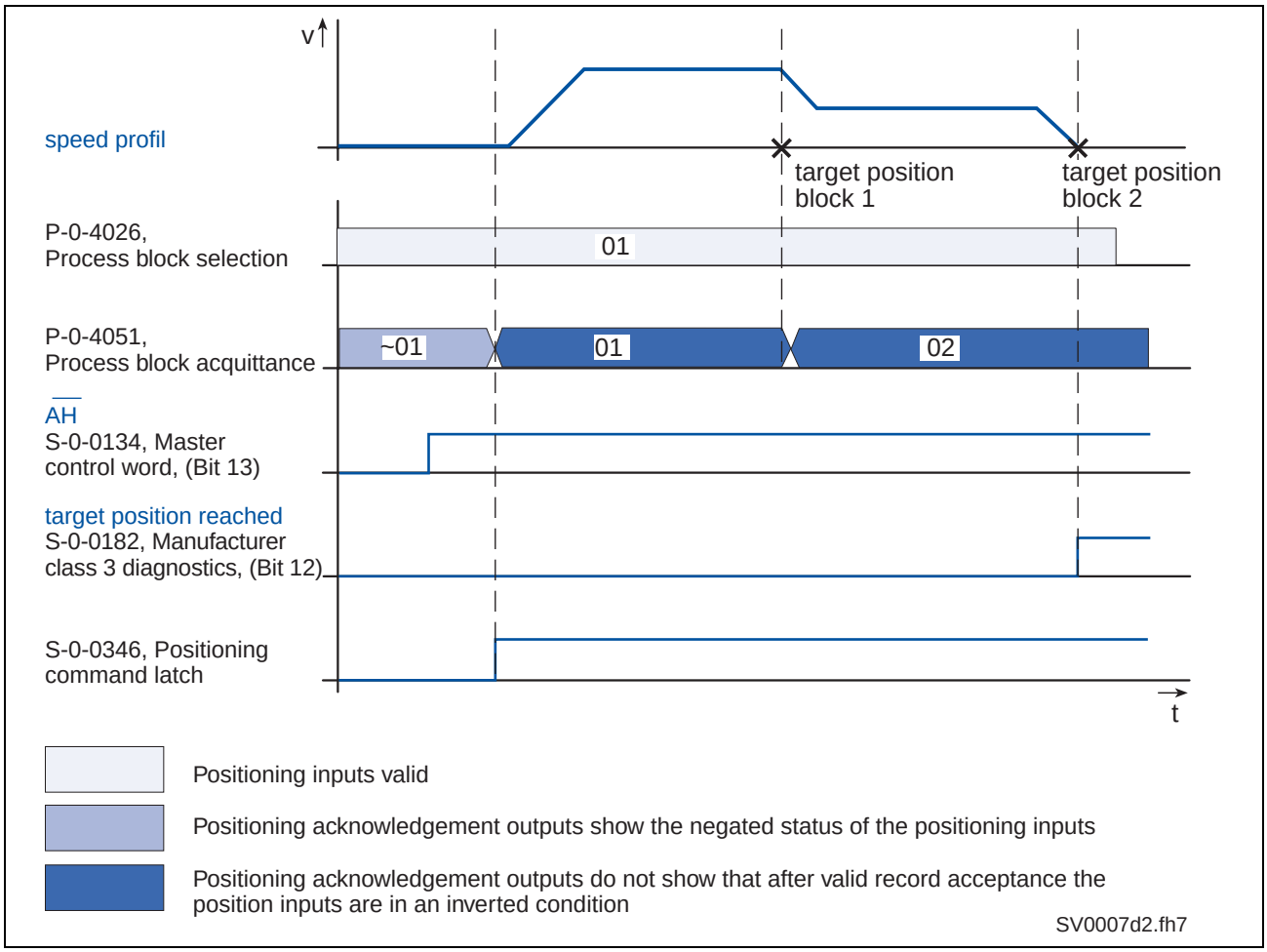

v
speed profil
target position block 1
target position block 2
P-0-4026, Process block selection
01
P-0-4051, Process block acquittance
~01
01
02
AH
S-0-0134, Master control word, (Bit 13)
target position reached
S-0-0182, Manufacturer class 3 diagnostics, (Bit 12)
S-0-0346, Positioning command latch
t
Positioning inputs valid
Positioning acknowledgement outputs show the negated status of the positioning inputs
Positioning acknowledgement outputs do not show that after valid record acceptance the position inputs are in an inverted condition
SV0007d2.fh7

Fig. 8-34: Example: Position-dependent block commutation (mode 1)

**b) Block transition with new positioning speed (Mode 2)**

P-0-4019, Process block mode =21h: absolute block with following block

P-0-4019, Process block mode =22h: relative block with following block

P-0-4019, Process block mode =24h: infinite block in positive direction with following block

P-0-4019, Process block mode =28h: infinite block in negative direction with following block

In following block mode 2, position-dependent block commutation means that the target position of the start block is run through at the positioning speed of the following block.

**Definition**

The drive runs in the direction of the target position $\mathbf{X_n}$ (with infinite blocks in set direction) set in **current position block n**. As the drive approaches $\mathbf{X_n}$, there is acceleration $\mathbf{a_n}$ to the **next** positioning speed $\mathbf{v_{n+1}}$ so that the speed $\mathbf{v_{n+1}}$ can be achieved prior to target position $\mathbf{X_n}$.

The switch to the next positioning block does not occur here either until the next target position is overrun.

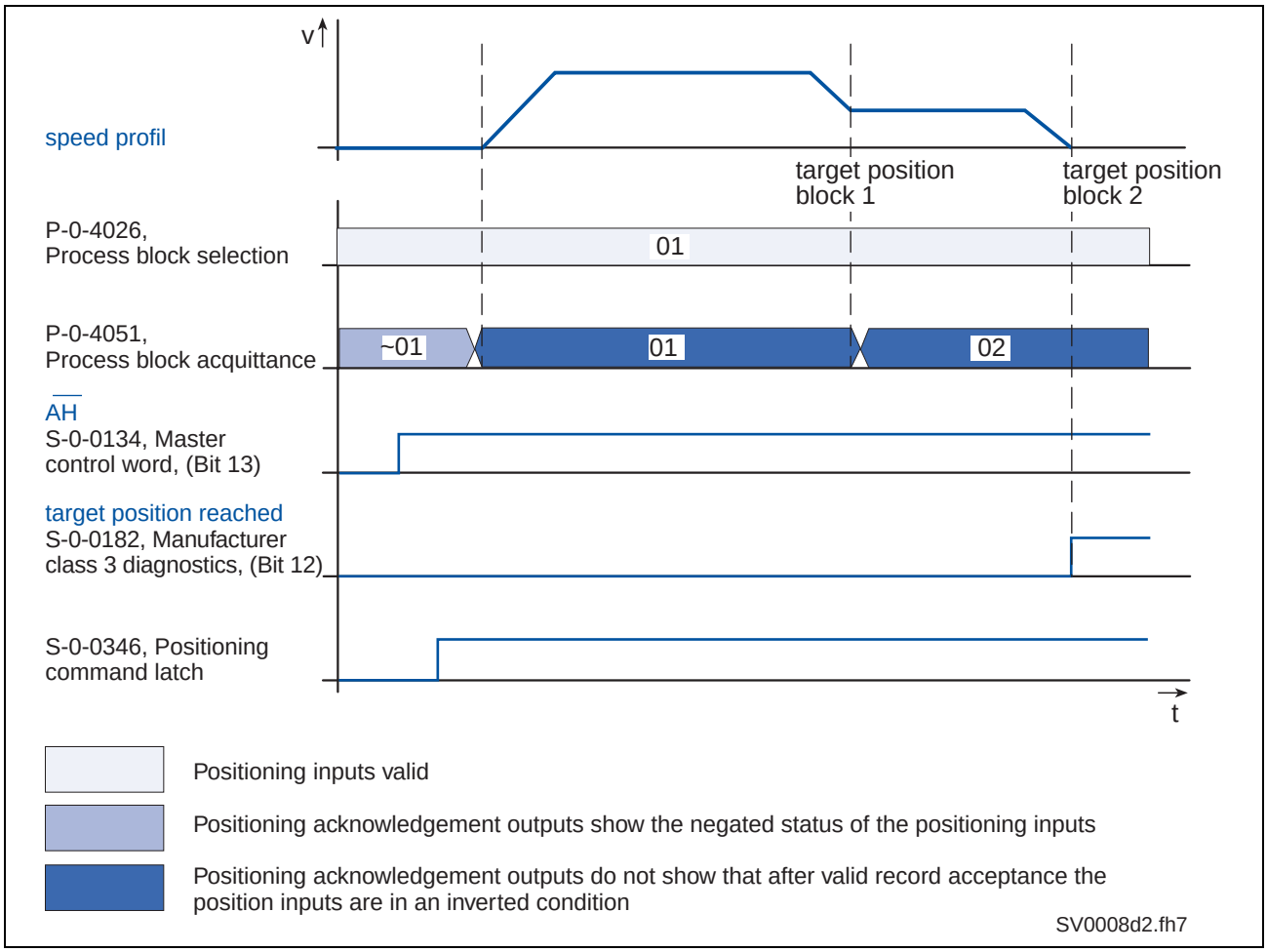

v
speed profil
target position block 1
target position block 2
P-0-4026, Process block selection
01
P-0-4051, Process block acquittance
~01
01
02
AH
S-0-0134, Master control word, (Bit 13)
target position reached
S-0-0182, Manufacturer class 3 diagnostics, (Bit 12)
S-0-0346, Positioning command latch
t
Positioning inputs valid
Positioning acknowledgement outputs show the negated status of the positioning inputs
Positioning acknowledgement outputs do not show that after valid record acceptance the position inputs are in an inverted condition
SV0008d2.fh7

Fig. 8-35: Example: Position-dependent block commutation (Mode2)

**c) Block transition with intermediate halt**

P-0-4019, Process block mode =41h : absolute block with following block

P-0-4019, Process block mode =42h : relative block with following block

With block commutation with intermediate stop, the drive positions at the target position of the start block. Once the position command is at the target position, the following block is automatically started without a new start signal generated externally.

**Definition**

As the drive approaches the target position, the drive is decelerated to speed 0 at the target position and then accelerated to the new positioning speed.

**Note:** Commutation takes place if the internal command value generator reaches the target position. Very small jerk values result in a creeping to target position which is like a dwell time.

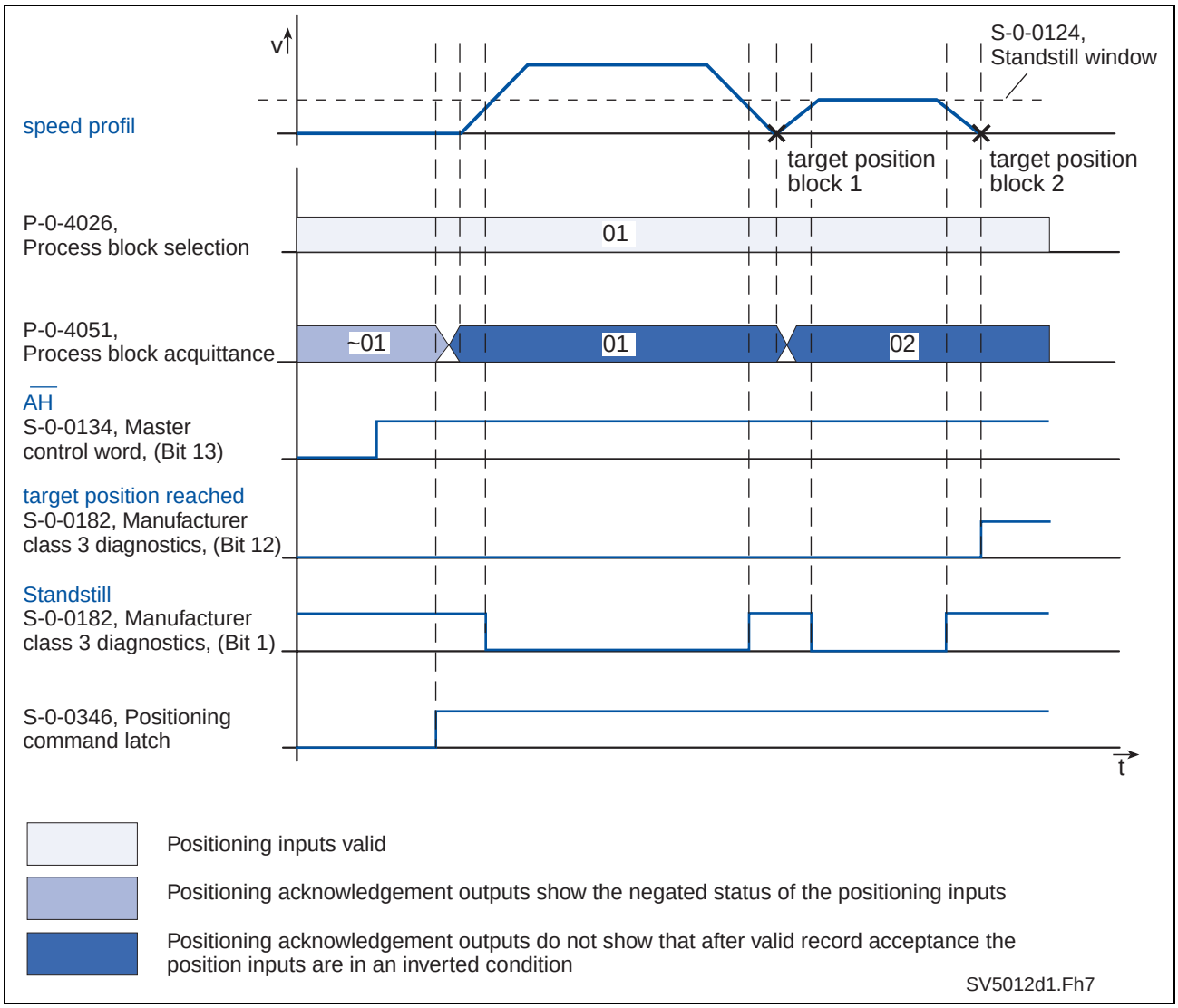



Fig. 8-36: Example: Following block commutation with target position with intermediate halt

**Note:** This mode should be used if there is a change in direction with two sequential following blocks within one following block change. Otherwise, the position at which the direction is to be changed will be overrun.

**2) Switching signal dependent block commutation**

P-0-4019, Process block mode = 81h: absolute block with following block

P-0-4019, Process block mode = 82h: relative block with following block

P-0-4019, Process block mode = 84h: infinite block in positive direction with following block

P-0-4019, Process block mode = 88h infinite block in negative direction with following block

Block commutation to a block with the next highest block number is triggered with an externally applied switching signal.

**Switching with cams**

The switching signal dependent block commutation makes a transition to a following block possible based on an external switching signal. As signal input the two following block inputs are available.

The state of the hardware signals is shown in parameter **P-0-4057, Positioning block, input linked blocks**.

**Definition**

The drive switches to the **next travel block** n+1 as soon as the input for the **following block cam 1** goes from **0->1**. If the target position is not reached then the new positioning block is switched into while travelling.

The drive switches to the **penultimate travel block** n+2 as soon as the input for the **following block cam 2** goes from **0->1**. If a following block cam is actuated during this run, then the drive switches to the positioning block after the next.

**Reference position**

A following relative positioning block references that position at which the following block cam was switched.

**Note:** The following block cams are checked ever 2 ms. The accuracy of the position detected therefore depends considerably on the speed at the time of overrun.

**Allocation table for cams**

| Cam 2 | Can 1 | Drive reaction |
|---|---|---|
| 0 | 0 | drive runs to target position of block n |
| X | 0->1 | block n+1 started |
| 0->1 | X | block n+2 started |

Fig. 8-37: Drive reaction with different switching signal sequences

X = Don't Care

n = positioning block selected via parallel inputs or parameter **P-0-4026, Process block selection**.

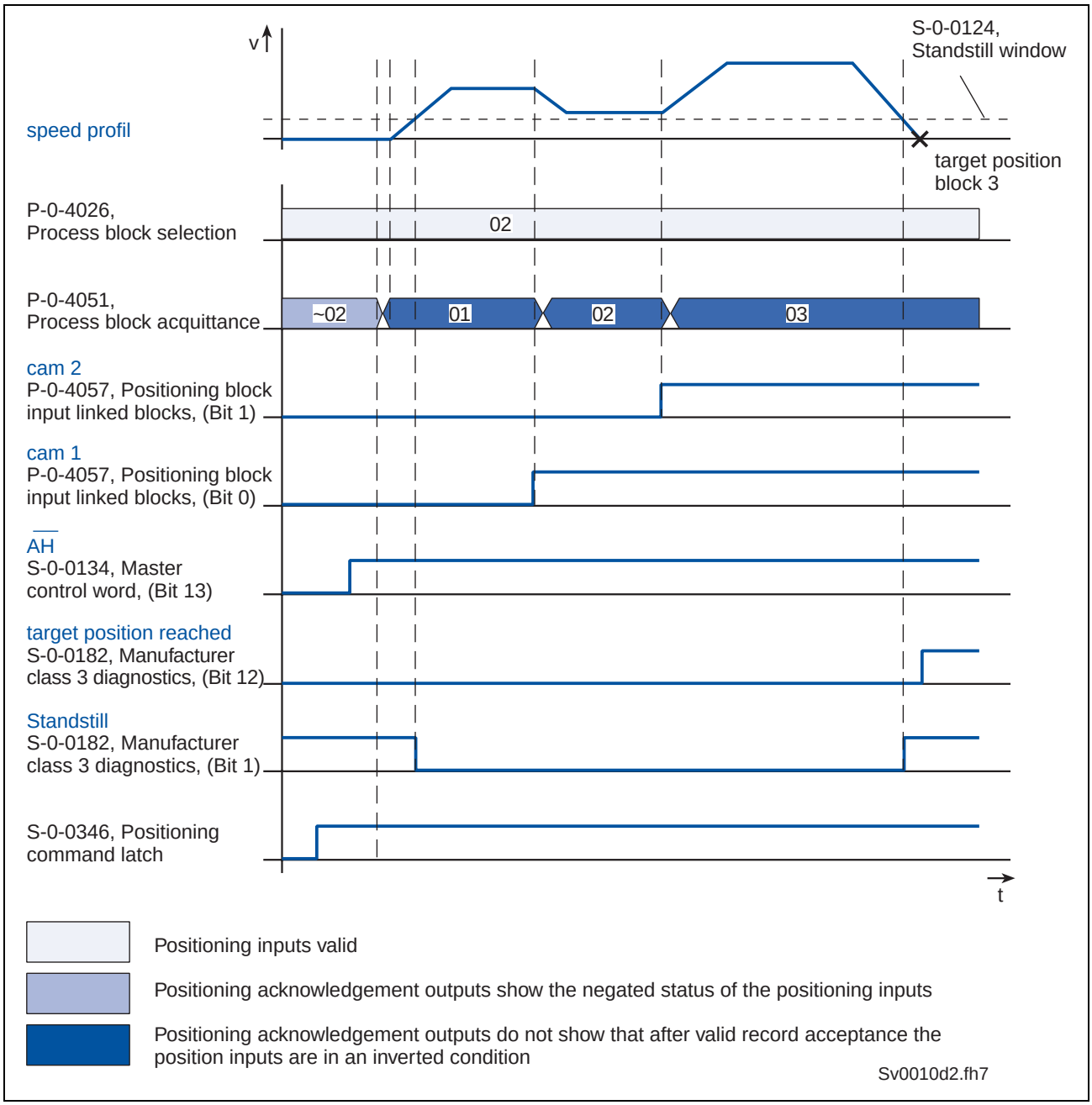



Fig. 8-38: Example: switching signal dependent block commutation

**No switching signal for block commutation**

If the start block of a switching-signal dependent following block is an absolute or relative positioning block, then the drive positions on target position if the switching signal for block commutation does not arrive. The drive thus generates the message "End position reached" after the following block chain is completed. If a switching signal is applied during the course of processing, then the drive will execute the following block.

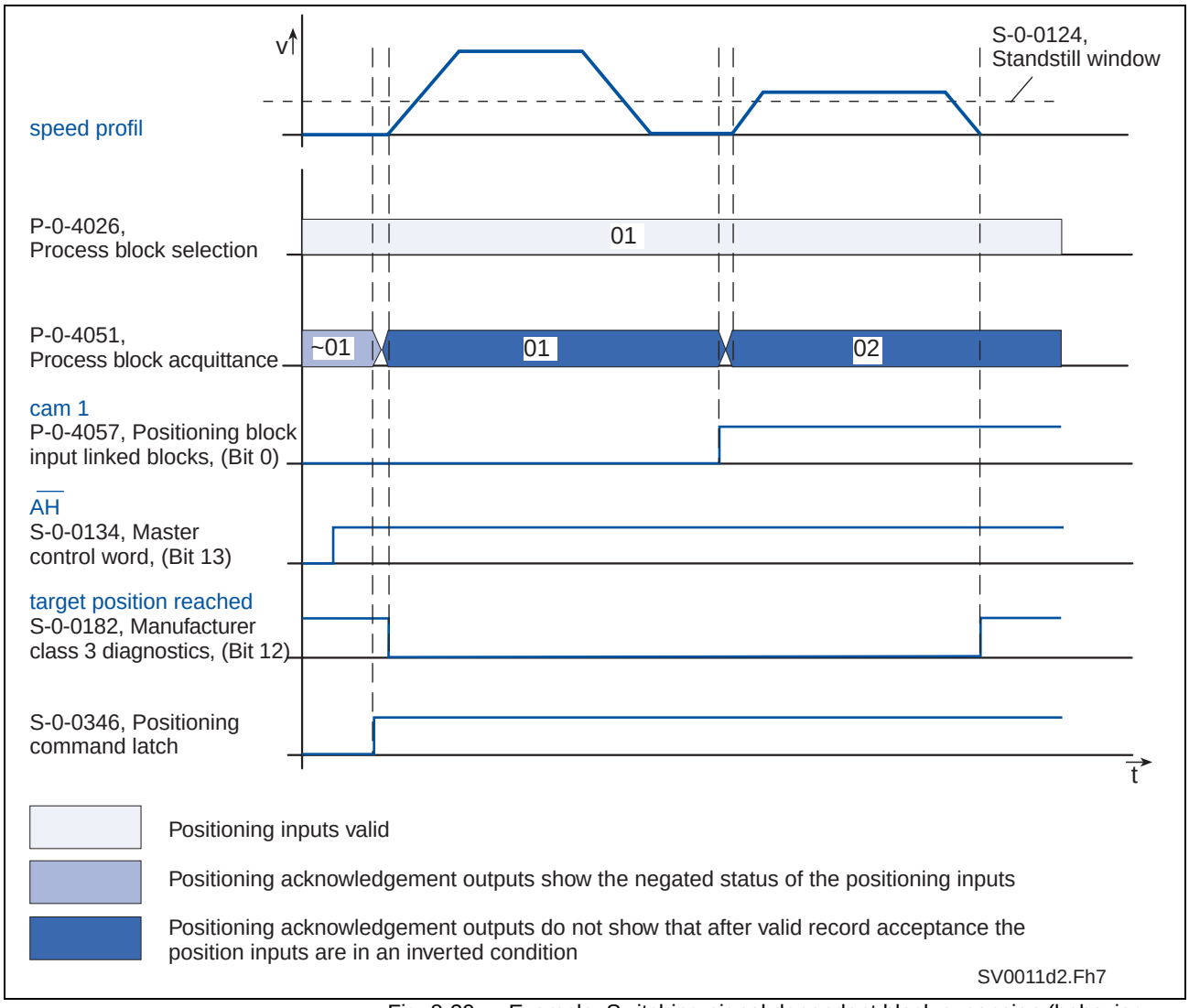



Fig. 8-39: Example: Switching-signal dependent block expansion (behavior with no switching signal)

**Note:** All four commutation conditions are constantly queried and evaluated to be able to switch to the correct following block even after the following block chain is interrupted. Only the first commutation conditions occurring during a break is recognized however. All others are not taken into account!

**Interrupting a following block chain**

An interruption can occur with

- a removal of the drive enable
- or a removal of the drive start signal.

Depending on the block type of the following block sequence that was interrupted and the events causing this interruption, the following block chain is processed differently after a restart.

**Note:** In following block mode relative positioning blocks without residual path storage are not allowed as otherwise the chain dimension reference will be lost.

**Interrupting a following block chain by selecting the same block number**

Given an interruption (e.g., with drive halt), a restart will end the following block chain.

**Reference position**

The reference position is the original start position of the block chain.

The chain is retained as only absolute and relative positioning blocks with residual path storage are used in following block mode!

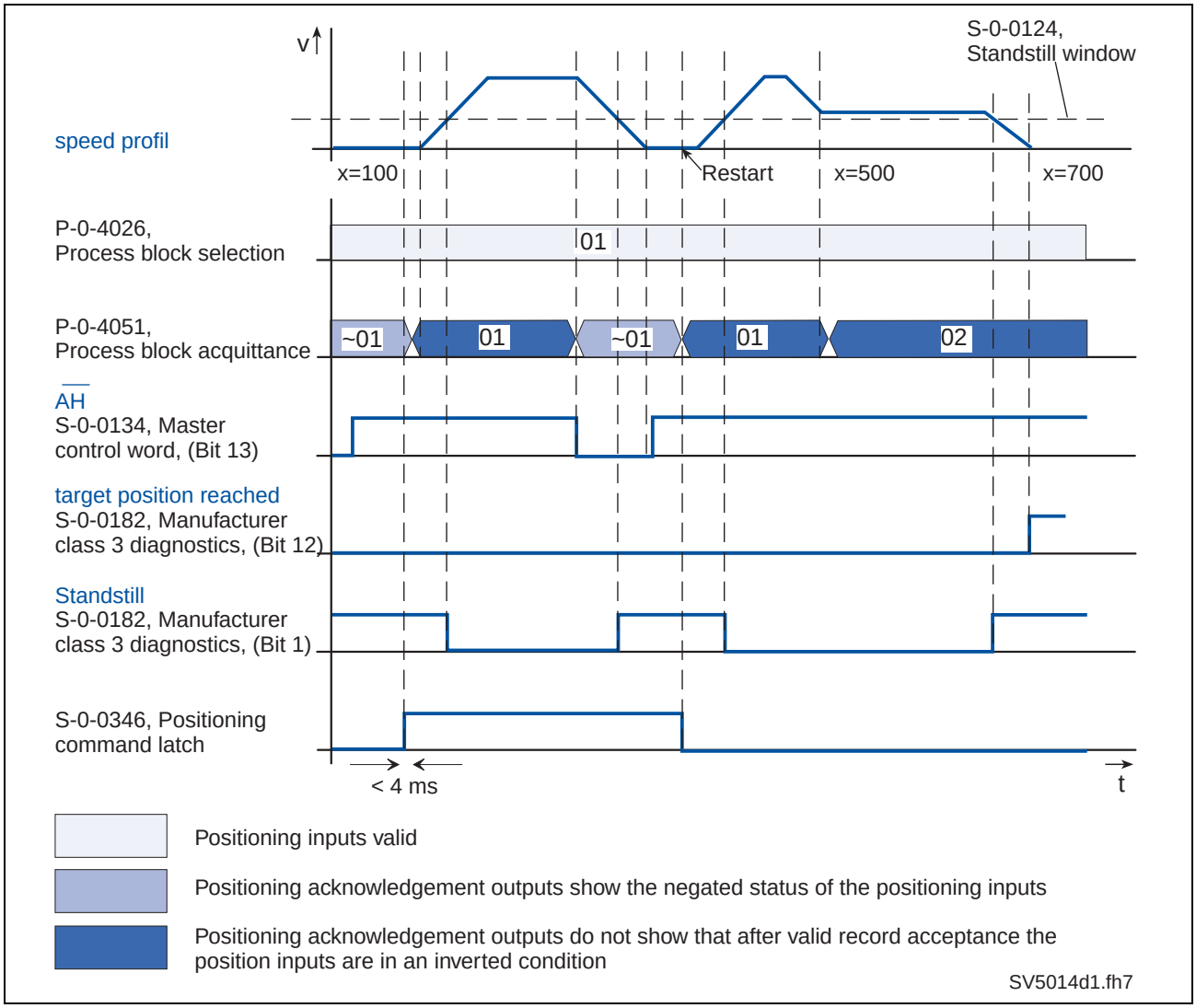



Fig. 8-40: Example: Following block interrupt with same block selected

**Changing into jog mode**

**Note:** Given a change into a different mode with an interrupt, the previously interrupt chain is completed upon restart unless a new block is selected. Given a following block with commutation due to target position means that only the overrunning of the target position of the current position block will be detected. The following block is completed from this position. The commutation conditions due to switching signals is always detected.

**Terminating a following block chain and selecting a new block number**

If a **new block number** is selected during an interruption (e.g., with drive halt), then the previously interrupted following block chain is **not completed** after a restart. Instead the current block is executed.

**Reference position** Current actual position value.

**Note:** The chain dimension reference is lost if the following block is interrupted.

The conditions for the interruption of following blocks also apply after the control voltage is switched off if an absolute encoder is used.

**Interrupting a following block chain with absolute following blocks** An interruption with absolute positioning blocks represents no problem as the absolute dimension is always guaranteed.

**.. when selecting a new block number** If a new block number is selected with an interruption, then the interrupted following block **is not completed** if **S-0-0346 Setup flag for relative command values,** is toggled. Instead, the current block is executed.

**.. with selecting the same block number** If the same block number is selected with an interruption, then the interrupted following block **is completed** if **S-0-0346, Setup flag for relative command values** is toggled.

# Parametrization notes for positioning blocks

## Taking drive limits into account

When parametrizing following blocks, the maximum values of the drive must be taken into account.

These are:

- maximum accel capability
- maximum speed (mains voltage dependent)

If blocks are parametrized that demand values greater than the maximum value of the drive, then this will generate an excessive lag error. The drive will signal error **"F228 Excessive deviation"** to indicate that it cannot comply with the position command value.

## Minimum values for accel and jerk

**General information** Accel values that are too small can also cause problems which is why the following should be taken into account with fixing the positioning blocks.

- **Minimum accel value**

$$acceleration > \frac{\text{speed difference}^2}{2t\,\text{arg}\,etposition difference} = \frac{\left(v_{n+1} - v_n\right)^2}{2 \cdot \left(X_{n+1} - X_n\right)}$$

$X_{n+1}$ = target position of the block n + 1

$v_n$ = block speed n

$v_{n+1}$ = block speed n + 1

Fig. 8-41: Minimum accel value with following block mode (translatory)

**Note:** The above relationship applies to a very large jerk, i.e., a jerk filter that has been switched off ( = 0 ). If such a filter is used, then the computed values are doubled. The stretch to be run with a block and its speed are generally fixed in percents. If the minimum accel value computed already causes the maximum value of the previous section to be exceeded, then a lower positioning speed must be selected.

- **Minimum jerk value**

If accel values are parametrized too small, then this could mean that the parametrized speed is not reached. What results is a "Triangular mode".

## Directional change within a following block chain

**Note:** If a directional change takes place when changing block n to block n+1 of a following block, then mode "Switching at target position with halt" should be used to reverse the direction without overshoot.

**Explanation** Following block n-1 with mode 1 following by following block n with intermediate halt, because a **change in direction** occurs when changing from block n to block n+1.

This means there is a sign change for the speed for target position n. If the accel parametrized in block n is too small to decel within the path difference = $X_n$-$X_{n-1}$ from speed $v_{n-1}$ to value 0, then the parametrized target position $X_n$ will be overrun.

This can cause software or hardware limit switches to trigger.

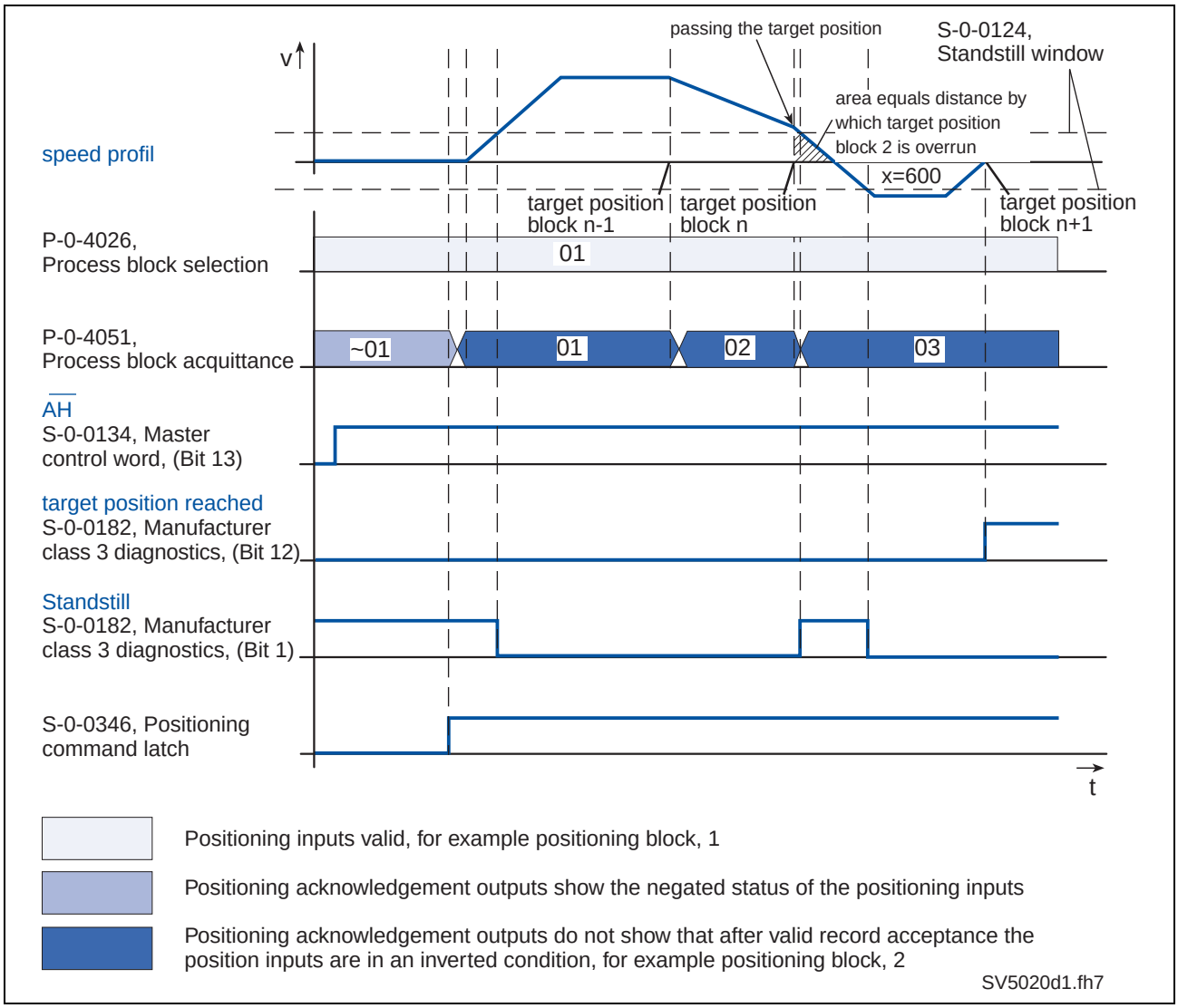



Fig. 8-42: Parametrizing a following block with directional change

**Note:** In this case it is necessary to take the rule of thumb into account for minimum acceleration to avoid overshooting of position!

## Acknowledge positioning block selected

### Acknowledging with active operating mode

After the positioning block mode is activated, the complement of the block number of the selected positioning block is acknowledged until a start signal (condition change **S-0-0346, Setup flag for relative/non-cyclic command values**) is generated. As of the first start signal and if operating is problem-free, the block number of the positioning block that has started, is generated. If an error is detected at the start of a positioning block then the faulty positioning block is acknowledged with the complement of the block number. The drive generates a warning and remains standing.

### Acknowledge with drive halt

If drive halt is active, then the complement of the block number of the selected positioning block is output in parameter **P-0-4051, Process block acquittance**.

### Acknowledge with auxiliary modes, error reaction or command settings

Acknowledgement is not effected, i.e., parameter **P-0-4051, Process block acquittance** retains its value.

### Acknowledge with drive enable removed

After removing the drive enable the **last accepted positioning block** is output. If the drive is at the target position of the last positioning block, then the message "**end position reached**" is additionally generated.

The example below shows the same absolute positioning block being started once more time.

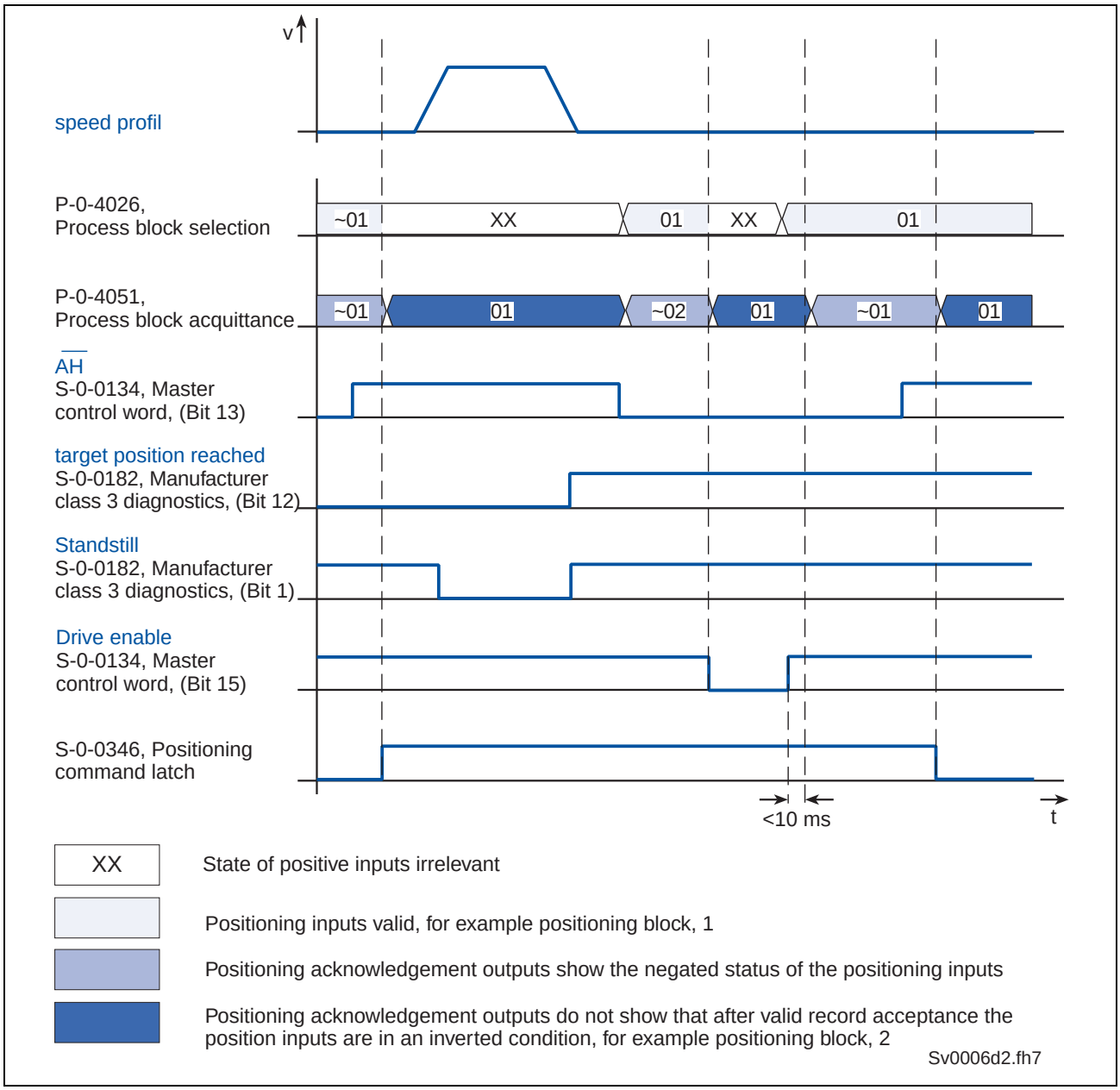



Fig. 8-43: Acknowledging and signalling "End position reached" after drive enable removed

## Acknowledge with control voltage interrupt

If the control voltage is switched off, then the last positioning block secured is stored in parameter **P-0-4052, Positioning block, last accepted.** This means that after powering up the last positioning block is output.

**Absolute encoder**

If an **Absolute encoder** is used, then it can be decided after the control voltage is switched off and on whether the drive is at the target position of the last positioning block (End position reached).

The "End position reached" message is fixed as soon as the drive is ready to operate again (bb contact closed).

**Single-turn encoder**

If a **Single-turn encoder** is used, then the "End position reached" message is not clearly defined after a power interrupt until the first target position is approached or referenced.

**Note:** The "End position reached" message is only retained if the axis is not moving during the interruption. If the axis is moved into the positioning window during the interruption, then the IN-POS message will also be generated. After activating the drive enable, positioning block acknowledge changes to as described in "Acknowledge with drive enable removed".

## Status Messages in "Positioning Block Mode"

In addition to the messages listed in section: "Status messages during drive-internal interpolation", the following status messages are also generated in positioning block mode:

- **End position reached**, Bit 12 of **S-0-0182, Manufacturer status class 3** is 1, it applies if:
  message "**In-target position**" (S-0-0182, Bit10) is active and no slave block has been selected.

## Diagnostic messages

- **E248 Interpolation acceleration = 0**
- **E249 Positioning velocity S-0-0259 > S-0-0091**
- **E253 Target position out of travel range**
- **E254 Not homed**
- **E255 Feedrate-override S-0-0108 = 0**
- **E258 Selected process block is not programmed**
- **E264 Target position out of num. range**

## Hardware Connections

See project planning manual

# 8.9 Operating Mode: Jogging

Operating mode is used to run an axis in "Manual mode", i.e., without the use of the control program.

## Pertinent Parameters

- **P-0-4030, Jog velocity**
- **P-0-4056, Jog inputs**
- **S-0-0260, Positioning Acceleration**
- **S-0-0193, Positioning Jerk**

**Note:** The parameters for the jog inputs are already present with SERCOS and fieldbus interfaces even though hardware inputs are not.

**Additional parameters**

- **S-0-0403, Position feedback value status**
- **S-0-0055, Position polarities**
- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**

**Note:** In the case of a fieldbus interface, it is possible to switch to jog mode by setting a bit in **P-0-4076, Fieldbus control word**.

# How it works

## Activating the operating mode jogging:

The jogging mode is active with a fieldbus interface if such has been selected via the control word.

The jog direction can be read out of parameter P-0-4056.

## Functional Sequence of operating mode jogging

Upon activation of the mode, the drive runs position controlled while maintaining the:

- speed limit value (**P-0-4030, Jog velocity**),
- acceleration limit value (**S-0-0260, Positioning Acceleration**)
- jerk limit value (**S-0-0193, Positioning Jerk**).

The Jogging direction is fixed in parameter **P-0-4056, Jog inputs**.

| Jog inputs | Drive | Display |
|---|---|---|
| 00b | stand still | AF |
| 01b | moving forward | JF |
| 10b | moving backward | Jb |
| 11b | stand still | AH |

Fig. 8-44: Relationship of jog input to travel direction

The drive positions itself at the relevant position limit (S-0-0049 or S-0-0050) if:

- position limit monitor is activated (**S-0-0055, Position polarity** Bit 4 = 1)
- and the drive has been homed (**S-0-0403, Position feedback value status** Bit 0 = 1)

**Note** If one of the above conditions has not been satisfied, then the drive continues to run infinitely in the set direction.

**Note:** The speed at which the drive moves when jogging can be influenced with the help of the Override function. Function Positioning at limited speed also has an immediate effect on the jog speed.

## Diagnostic Messages

Warning "**E831 Position limit reached during jog**" is generated if the drive positions at the position limit value.

The warning is cleared:

- once the mode is changed and
- after jogging in the opposite direction.

# 8.10 Operating mode: velocity synchronization with virtual master axis

Velocity synchronization is used in printing machines in such cases as simple transport feeds. The drive runs with velocity synchronous to the master axis. The track speed at the circumference of the transport feed or the winder is preset by the electrical gear. A defined tension control can be set with the fine offset of the gear.

The master axis position is set in this mode by the control.

The structure of the mode is illustrated below:

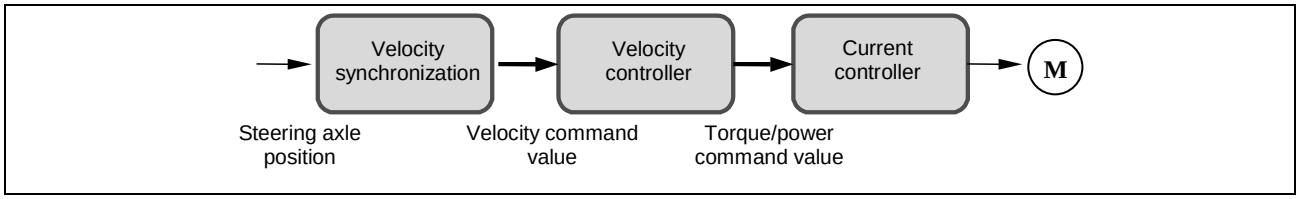



Fig. 8-45: Velocity Synchronization with virtual master axis block diagram

## Pertinent Parameters

- **S-0-0236, Master drive 1 revs.**
- **S-0-0237, Slave drive 1 revs.**
- **P-0-0083, Gear ratio fine adjust**
- **P-0-0053, Master drive position**
- **P-0-0108, Master drive polarity**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**

## Command Value Preparation for Velocity Synchronization with Virtual Master Axis

After the slave drive has been synchronized to the master axis position, the drive generates the "synchronous velocity command value" (This is a component of the velocity command value which is relayed to the velocity controller).

The synchronous velocity command value (dXsynch) is selected for the master drive in terms of the polarity (**P-0-0108, Master drive polarity**) and the set scaling type **(S-0-0076, Position data scaling type)** in accordance with the following equation:

$$dX_{Synch} = \pm\ [(P\text{-}0\text{-}0053_{(n)} - (P\text{-}0\text{-}0053_{(n-1)}) * \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * \frac{S\text{-}0\text{-}0237}{S\text{-}0\text{-}0236} * (1 + P\text{-}0\text{-}0083)]$$

dXSynch: synchronous velocity command value
n: probe cycle

Fig. 8-46: Generating the synchronous velocity value for rotary scaling

The fine adjustment of the gear ratio that can be configured as cyclical data permits velocity changes at the slave axis at a constant master axis speed. Velocity can also be changed by changing the master axis gear parameter which can also be cyclically changed.

The following illustrates how the velocity command value is generated.

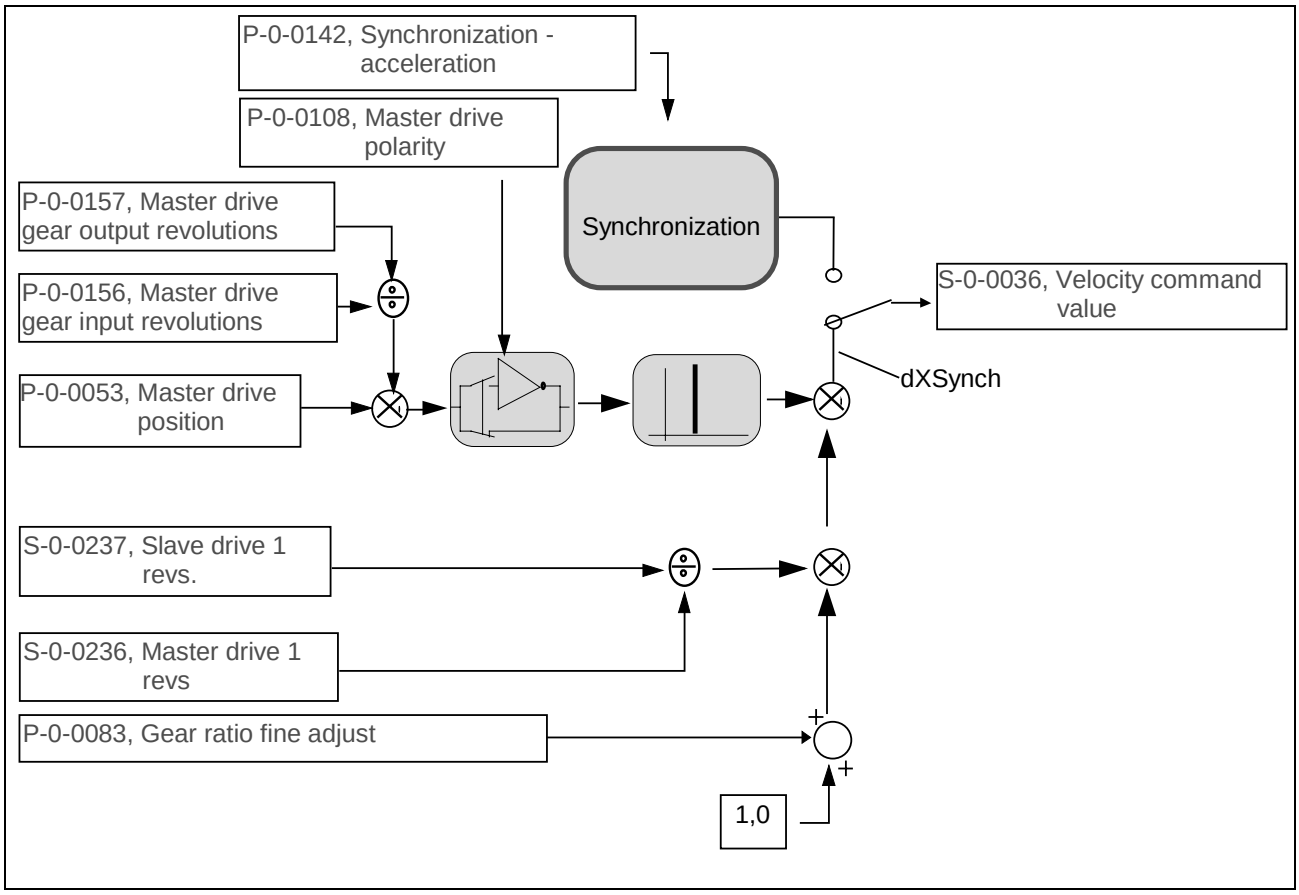



Fig. 8-47: Command value prep for velocity synchronisation

see also "Velocity Controller"

see also "Current Controller"

## Dynamic synchronization in the velocity synchronization operating mode

Associated parameters:

- **P-0-0142, Synchronization acceleration**

Dynamic synchronization is included in the velocity synchronization operating mode.

It consists of drive-controlled acceleration or deceleration, with a target of synchronous velocity.

The synchronization procedure starts when the velocity synchronization mode is activated. A velocity command profile is generated starting with the feedback velocity at the time of activation, and ending with the synchronous velocity command value. The synchronization acceleration is used to generate this profile.

Following synchronization, the velocity command values are determined solely by the synchronous velocity command values.

In velocity sychronization mode, the drive operates with velocity loop control.

### Synchronization status message during the velocity synchronization operating mode

Associated parameters:

- **S-0-0037, Additive velocity command value**
- **S-0-0040, Velocity feedback value**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0183, Velocity synchronization window**

The drive sets bit 8 in the Manufacturer Class 3 diagnostics if:

| dXSynch + S-0-0037 - S-0-0040 | < S-0-0183

**Note:** The bit is updated only if the velocity synchronization operating mode is set in the **S-0-0032**, **Primary mode of operation**.

## 8.11 Operating mode: velocity synchronisation with real master axis

Analog to velocity synchronisation mode with virtual master axis, this operating mode is used in printing machines.

The master axis position in this case is detected by means of a master axis encoder.

This operating mode can also be set for use with a DKC01.3. No cyclical command communications for command value specification is needed.

The relevant status messages can be applied via the freely-configurable signal status word to the digital outputs.

The structure of the operating mode is illustrated below.

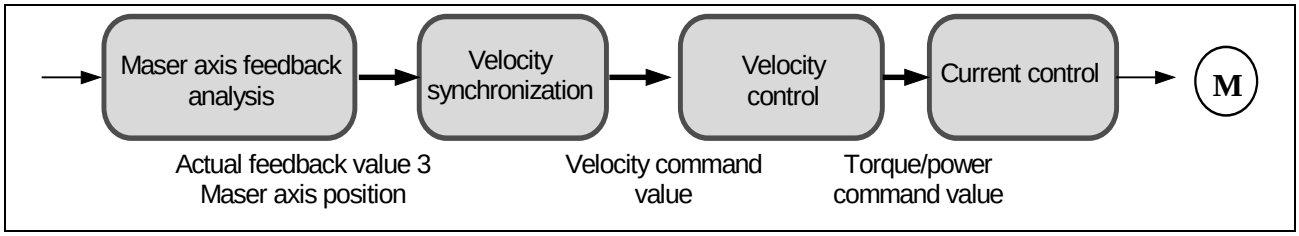



Fig. 8-48: Velocity synchronisation with real master axis block diagram

## Pertinent Parameters

The parameters listed in the sections "Velocity synchronisation with virtual master axis" and "Master axis evaluation" are involved here.

## Functional Principle

This mode combines the function of master axis encoder and velocity synchronisation in the drive.

The master axis encoder supplies **P-0-0052, Position feedback value 3,** which is copied by the drive into parameter **P-0-0053, Master drive position**.

The function of the individual function blocks is described in the relevant sections:

see chapter: "Master Axis Feedback Analysis"

see chapter: "Operating mode: velocity synchronization with virtual master axis"

see chapter: "Velocity Controller"

see chapter: "Current Controller"

**Note:** If the master axis encoder (incremental encoder) is not homed then zero pulse detection is automatically activated. As soon as the zero pulse is generated, there is a position jump to the value **P-0-0087, Offset position feedback value 3**. The resulting velocity jump is suppressed. The automatic referencing of the master axis encoder can be switched off in parameter **P-0-0185, Function of encoder 2**.

# 8.12 Operating mode: phase synchronisation with virtual master axis

In machining processes that need absolute phase synchronisation, e.g., printing, punching or perforating in printing machines, then the position relevant to the master axis is established in operating mode phase synchronisation.

The drive synchronizes in this mode to one of the master axis positions set by the control (virtual) (P-0-0053).

The structure of the phase synchronisation mode with virtual master axis is illustrated below:

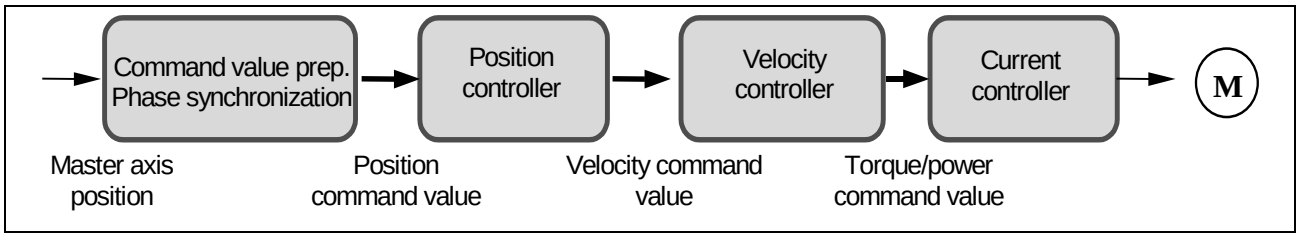



Fig 8-49: Virtual phase synchronisation block diagram

## Pertinent Parameters

- **S-0-0048, Position command value additional**
- **S-0-0236, Master drive 1 revolutions**
- **S-0-0237, Slave drive 1 revolutions**
- **P-0-0053, Master drive position**
- **P-0-0108, Master drive polarity**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**
- **P-0-0159, Slave drive feed travel**

## Command value preparation with phase synchronisation with virtual master axis

In phase synchronisation mode with a virtual master axis the position command value is generated by adding the synchronous position command value (**XSynch)** and **S-0-0048, Position command value additional**.

$$S\text{-}0\text{-}0047 = XSynch + S\text{-}0\text{-}0048$$

S-0-0047, Position command value
XSynch: synchronous position command value
S-0-0048, S-0-0048, Position command value additional

Fig. 8-50: Generating the position command value

The synchronous position command value (Xsynch) is calculated in terms of the selected polarity for the master drive (**P-0-0108, Master drive polarity**) and the scaling type **(S-0-0076, Position data scaling type)** using the following formula:

$$X_{Synch} = \pm\ P\text{-}0\text{-}0053\ *\ \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * \frac{S\text{-}0\text{-}0237}{S\text{-}0\text{-}0236}$$

XSynch: synchronous position command value

Fig. 8-51: Generating the synchronous position command value with rotary scaling

$$X_{Synch} = \pm\ P\text{-}0\text{-}0053\ *\ \frac{P\text{-}0\text{-}0157}{P\text{-}0\text{-}0156} * \frac{P\text{-}0\text{-}0159}{S\text{-}0\text{-}0236}$$

XSynch: synchronous position command value

Fig. 8-52: Generating the synchronous position command value with translatory scaling

**Note:** The master axis position is fixed at 2^20 increments per master axis revolution.

**Note:** The synchronous position command value is generated after the slave drive is synchronized to the master axis position.

**Note:** The electronic gearbox generated with the above formular with the help of parameters S-0-0237/S-0-0236 or P-0-0159/S-0-0236 can be precisely set (32 bit).
Parametrization can, however, not take place during processing but only in parametrization mode (Phase 2).
The electronic gearbox generated by the parameter P-0-0157/P-0-0156 is less precise (16 bits), but it can be changed during processing. A dynamic fine adjustment can be executed meaning that a reaction to dynamically changeable gearbox ratios is possible.

The following illustrates how the position command value is generated using the formula above.

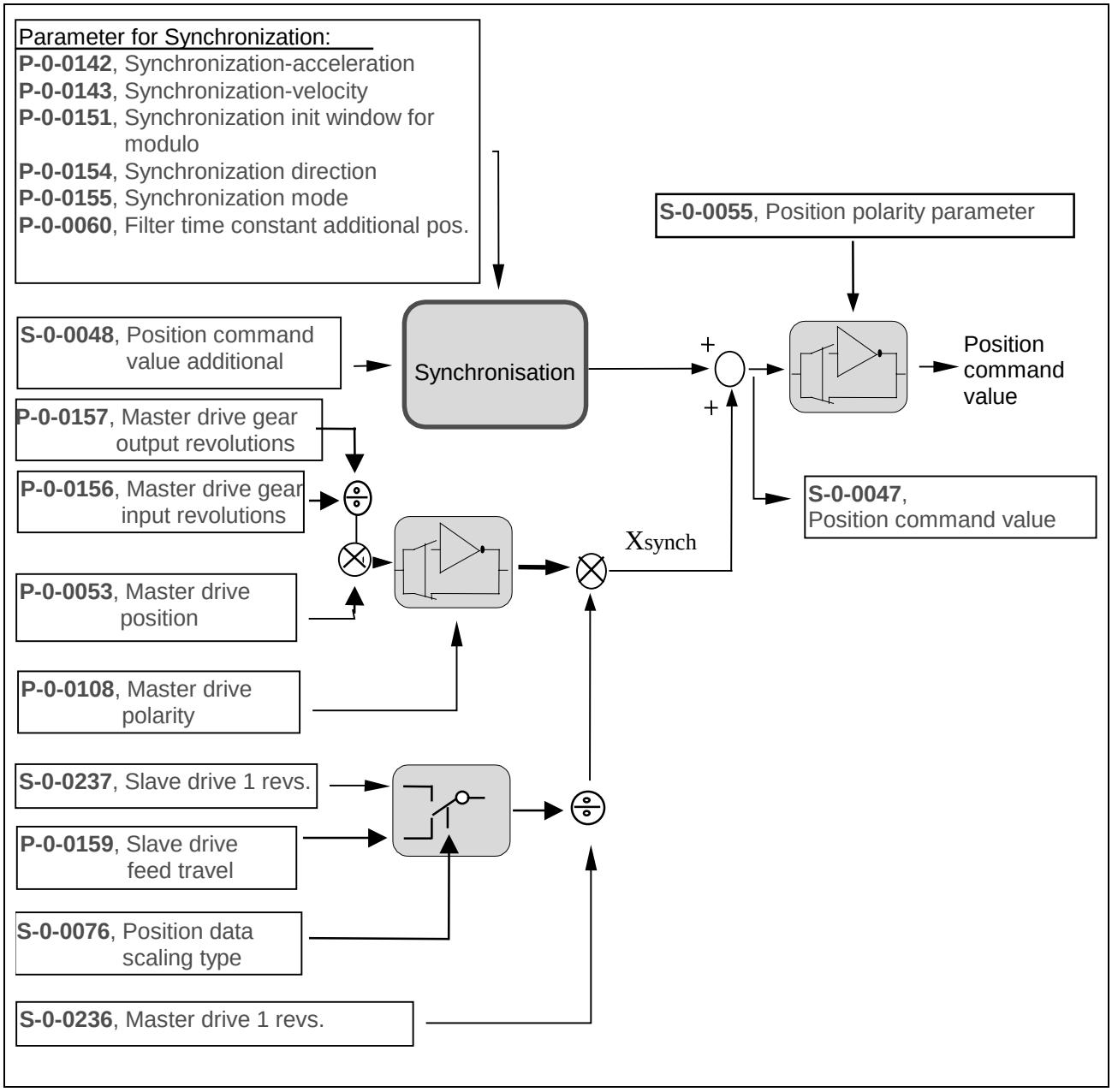



Fig. 8-53: Command value preparation to phase synchronisation

See also "Position Controller"

See also "Velocity Controller"

See also "Current Controller"

## Dynamic Synchronisation in the Phase Synchronisation Operating Mode

Associated parameters:

- **S-0-0048, Position command value additional**
- **P-0-0060, Filter time constant additional pos. command**
- **P-0-0142, Synchronisation acceleration**
- **P-0-0143, Synchronisation velocity**
- **P-0-0151, Synchronisation init window for modulo format**
- **P-0-0154, Synchronisation direction**
- **P-0-0155, Synchronisation mode**

Dynamic synchronisation is included in the phase synchronisation operating mode.

It consists of drive-controlled move with a target of absolute synchronisation.

A synchronisation operating mode with supported position control is performed during synchronisation **in two steps**.

**Step 1:**

Upon activating the operating mode, a velocity adjustment is first executed.

This means that the drive either accelerates or decelerates from the feedback velocity at the time of activation to the synchronous velocity.

The drive generates the synchronous velocity by differentiating the synchronous position command value. These synchronous position command values XSynch are generated in terms of the operating mode out of **P-0-0053, Master drive position**.

Velocity adjustment takes place in position control. When accelerating or braking, the drive takes **P-0-0142, Synchronisation acceleration** into account.

After velocity adjustment is complete, there is a difference between the active position command value and the sum of the synchronous position command values XSynch and **S-0-0048, Position command value additional.**

**Step 2:**

The second step of dynamic synchronisation is position adaptation. The drive moves a distance equal to the difference described above. It generates a position command profile that is added to the synchronous position command value. This profile is determined by the **P-0-0142, Synchronisation acceleration** and **P-0-0143, Synchronisation velocity** parameters.

The path is generated according to the following equation:

| Path = XSynch + S-0-0048 - S-0-0047 |
|---|

Xsynch: synchronous position command value

Fig. 8-54: Determining the travel path

Given an absolute shaft, the path is traversed as calculated.

Given a modulo shaft, the path first is limited to the +/- **S-0-0103, Modulo value**. The **P-0-0154, Synchronisation direction** and **P-0-0151, Synchronisation init window for modulo format** parameters are taken into consideration.

**Note:** The synchronisation direction parameter will only work if the shortest path ( when <= 0.5 * modulo value) is larger than the synchronisation window. Then, the synchronisation direction will be set with the parameter (positive, negative or shortest path).
If the shortest path is smaller than the synchronisation window, then the shortest path will always be travelled.

The drive will be in absolute synchronisation at the conclusion of the second synchronisation step. The drive sets bit 9 in parameter **S-0-0182, Manufacturer class 3 diagnostics** ("Synchronisation concluded").

The following applies:

**S-0-0047, Position command value** = XSynch + **S-0-0048, Position command value additional**

Every time the additive position command value (S-0-0048) is changed, a new path will be determined and traveled according to the above equation, using parameters P-0-0142, P-0-0143, P-0-0151 and P-0-0154.

**P-0-0155, Synchronisation mode**

The **P-0-0155, Synchronisation mode** parameter can be used to optionally switch off the dynamic synchronisation after first reaching absolute synchronisation.

If synchronisation mode 1 is set, then parameters

**P-0-0142, Synchronisation acceleration**

**P-0-0143, Synchronisation velocity**

**P-0-0151, Synchronisation init window for modulo format**

**P-0-0154, Synchronisation direction**

will be inoperative after absolute synchronisation is reached.

Changes to the additional position command value will be smoothed with a filter of the first order. The time constant for the filter will be set with the parameter **P-0-0060, Filter time constant additional pos. command**.

If parameter **P-0-0155, Synchronisation mode** bit = 1 then bit "Synchronisation completed" is set and not cleared even with further changes in **S-0-0048, Position command value additional**.

If the dynamic synchronisation remains active (**P-0-0155, Synchronisation mode** bit = 0), then the bit will be set only if the above equation is satisfied.

The following graphics show the time flow of the velocity for the standard and filter synchronisation modes.

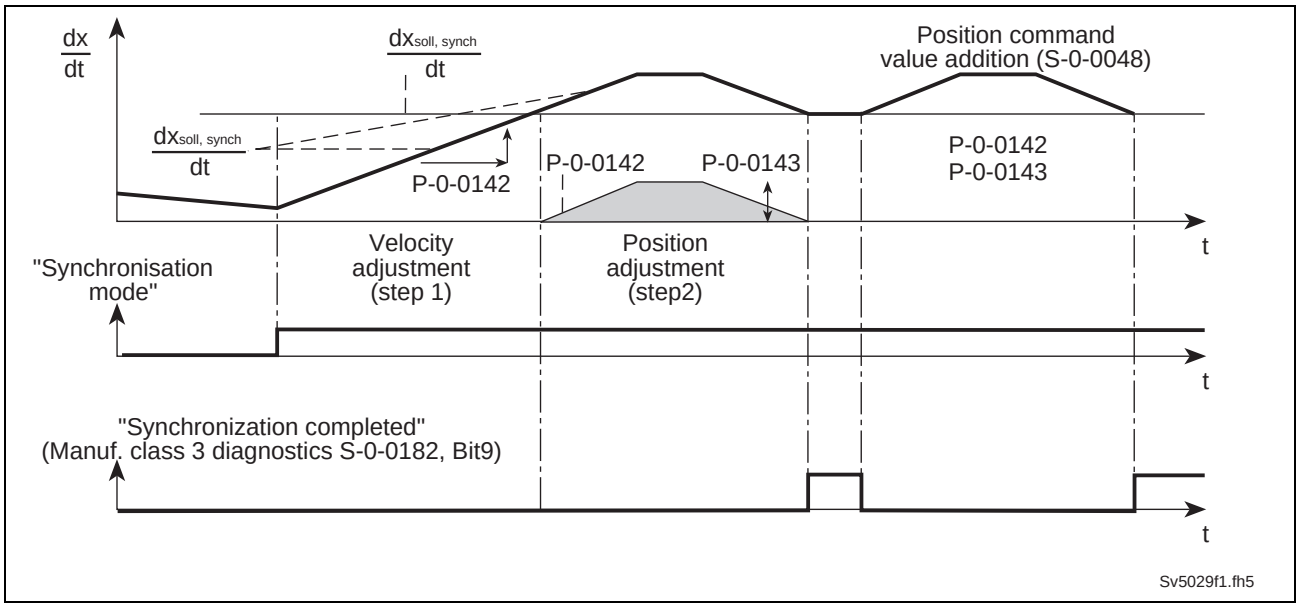



Fig. 8-55: Standard Synchronisation Mode (P-0-0155 = 0)

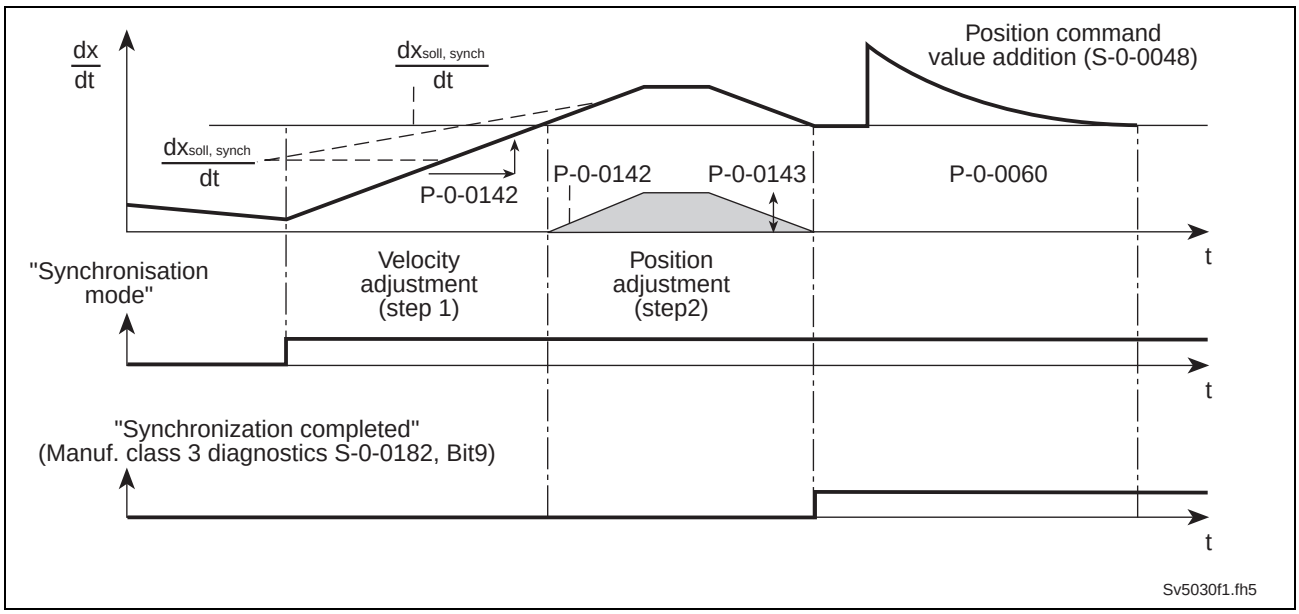



Fig. 8-56: Synchronisation mode of register controller (P-0-0155 = 1)

**P-0-0155, Synchronisation mode bit 1 =1:**

After the operating mode is activated, only step 1 of the synchronisation procedure is conducted. This realizes a relative position-synchronous slave axis. To do this, parameter **S-0-0048, Position command value additional** is synchronized by the drive in such a way that there is no second step to the synchronisation process.
A phase offset is nonetheless possible by changing parameter **S-0-0048, Position command value additional**.

### Synchronisation status message for the phase synchronisation operating mode

Associated parameters:

- **S-0-0048, Position command value additional**
- **S-0-0051, Position feedback value 1 (motor feedback)**
- **S-0-0053, Position feedback value 2 (ext. feedback)**
- **S-0-0182, Manufacturer class 3 diagnostics**
- **S-0-0228, Position synchronisation window**

The drive sets bit 8 in the Manufacturer Class 3 diagnostics if:

| XSynch + **S-0-0048** - (**S-0-0051** or **S-0-0053**) | < **S-0-0228**

The bit will be set only if a synchronisation operating mode is selected in the **S-0-0032, Primary mode of operation**.

During the first phase of dynamic synchronisation (velocity adaptation), the bit will be set to 0 to avoid being set too early for a modulo shaft.

## 8.13 Operating mode: phase synchronization with real master axis

In machining processes that require an absolute angle synchronization, such as printing, stamping or perforating in printing machines, the position relationship to the master axis is generated in angle synchronization mode.

In this mode, the drive synchronizes to a (real) master axis position generated from the master axis encoder.

The structure of the mode angle synchronization with real master axis is illustrated below:

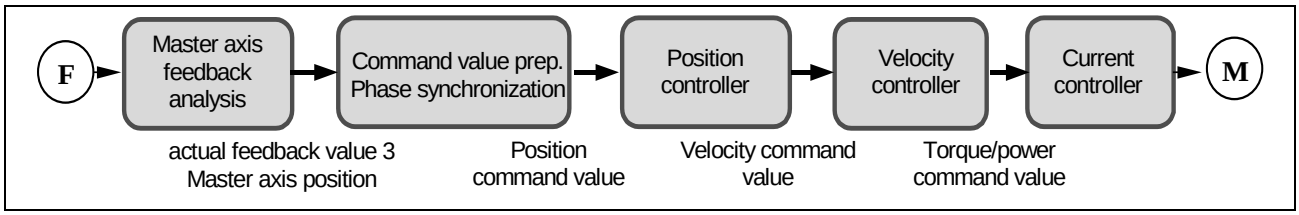



Fig. 8-57: Real Phase Synchronization Block Diagram

## Pertinent Parameters

The parameters listed in sections: "Operating mode: phase synchronisation with virtual master axis" and "Master Axis Feedback Analysis" are involved in this mode.

## Functional Principle

the modes "Phase synchronization with virtual master axis“ and the master axis encoder evaluation are combined in the drive. The master axis encoder evaluation gained in **P-0-0052, Position feedback value 3** is copied by the drive into parameter **P-0-0053, Master drive position**.

The function of the individual function blocks is described in the relevant sections.

see section: "Master Axis Feedback Analysis"

see section: "Operating mode: phase synchronisation with virtual master axis"

see section: "Position Controller"

see section: "Velocity Controller"

see section: "Current Controller"

---

**Note:** As long as the master axis encoder has not been referenced (position status Bit 2 = 0) the drive follows the master axis position velocity synchronously. The dynamic synchronization is begun as soon as the master axis encoder has been absolutely evaluated (referenced) and the synchronous velocity has been reached.

---

With dynamic synchronization the path is increased by the position jump of the master axis encoder position when detecting the zero pulse.

| Path = XSynch + **S-0-0048** - **S-0-0047 +(P-0-0052[n]-P-0-0052[n-1])** |
|---|

XSynch: synchronous position command value

Fig. 8-58: Travel path for absolute synchronisation

It applies:

P-0-0052[n] = P-0-0053[n] = Position of the master axis encoder directly after detection of zero pulse.

P-0-0052[n-1] = P-0-0053[n-1] = Position of the master axis encoder indirectly after detection of the zero pulse.

# 8.14 Operating mode: electronic cam shaft with virtual master axis

In electronic cam mode with virtual master axis there is a fixed relationship between the master axis position and the slave axis.

The (virtual) master axis position is set by the control.

The structure of the mode "Electronic cam with virtual master axis" is illustrated below:

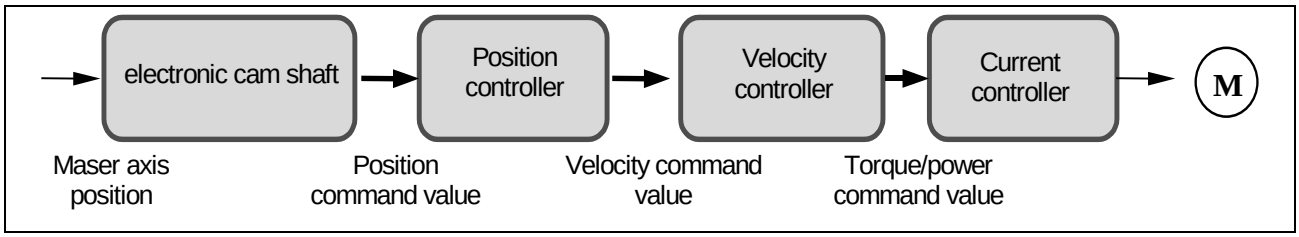



Fig 8-59: Electronic cam shaft block diagram

see also "Position Controller"

see also "Velocity Controller"

see also "Current Controller"

## Pertinent Parameters

- **S-0-0048, Position command value additional**
- **P-0-0053, Master drive position**
- **P-0-0061, Angle offset begin of profile**
- **P-0-0072, Cam shaft profile 1**
- **P-0-0085, Dynamical phase offset**
- **P-0-0088, Cam shaft control**
- **P-0-0089, Cam shaft status**
- **P-0-0092, Cam shaft profile 2**
- **P-0-0093, Cam shaft distance**
- **P-0-0094, Cam shaft switch angle**
- **P-0-0108, Master drive polarity**
- **P-0-0144, Cam shaft distance switch angle**
- **P-0-0156, Master drive gear input revolutions**
- **P-0-0157, Master drive gear output revolutions**
- **P-0-0158, Phase offset velocity**

## Command Value Preparation for Electronic Cam

Upon activation of this mode, the position command value of the drive is initialized in terms of the following relationship.

$$X_{F(\varphi L)} = h * tab(\pm\varphi_L * \frac{G_a}{G_e} - \varphi_V) + X_v$$

$X_F$ : S-0-0047, Position command value
+/- : P-0-0108, Master drive polarity (P-0-0108=1 > -)
$\varphi_L$ : P-0-0053, Master drive position
$\varphi_V$ : P-0-0061, Angle offset begin of profile
h: P-0-0093, Cam shaft distance
tab(φ): P-0-0072, Cam shaft profile 1 or P-0-0092, Cam shaft profile 2
$X_v$: S-0-0048, Position command value additional
$G_a$: P-0-0157, Master drive gear output revolutions
$G_e$: P-0-0156, Master drive gear input revolutions

Fig. 8-60: Initializing the position command value

If a mode is activated then the differences of the master axis position are processed to ensure a consistent run of the position command value given changes in the cam offset or hub parameters.

The difference to the last control cycle is generated out of the cam table in each control cycle and then processed in accordance with the formula.

If table limits are exceeded in a positive direction, then the table starts over at the beginning. The same happens in a negative direction.

The position command value generated as per the following relationship:

$$X_{F(n)}(\varphi L) = X_{F(n-1)}(\varphi L) + (h * \Delta tab(\pm \varphi L * \frac{G_a}{G_e} - \varphi V + \varphi d) + X_V)$$

+/- : P-0-0108, Master drive polarity (P-0-0108=1 > -)
$X_{F(n)}$ : **pos. com. value of slave drives** S-0-0047 in current control cycle
$X_{F(n-1)}$ : **pos. com. value of slave drives** S-0-0047 in the last control cycle
$\varphi_L$ : P-0-0053, Master drive position
$\varphi_V$ : P-0-0061, Angle offset begin of profile
$\varphi_d$ : dynamic angle offset, see following formula
h: P-0-0093, Cam shaft distance
tab(φ): P-0-0072, Cam shaft profile 1 or P-0-0092, Cam shaft profile 2
Xv: S-0-0048, Position command value additional
$G_a$: P-0-0157, Master drive gear output revolutions
$G_e$: P-0-0156, Master drive gear input revolutions

Fig. 8-61: Bildung des Lagesollwertes für den Folgeantrieb

**Changes of P-0-0061, Angle offset begin of profile**

To avoid jumps of the table access angle, a new value for parameter **P-0-0061, Angle offset begin of profile** does not immediately become effective. Starting with the current value, a ramp-like approximation of the new value is conducted. The approximation is conducted along the shortest possible path. The ramp is set in parameter **P-0-0158, Phase offset velocity**.

**P-0-0085, Dynamical phase offset**

Parameter **P-0-0085, Dynamical phase offset** is used to compensate a lag error if the position controller has not been set to lag-free control. The table access angle is set prematurely and is velocity-dependent.

$$\varphi d = \frac{P\text{-}0\text{-}0085 * (\varphi L(n) - \varphi L(n-1)) * \frac{G_a}{G_e})}{Kv}$$

$\varphi_L$: P-0-0053, Master drive position
P-0-0085: Dynamical phase offset
$G_a$: P-0-0157, Master drive gear output revolutions
$G_e$: P-0-0156, Master drive gear input revolutions
Kv: S-0-0104, Position loop Kv-factor

Fig. 8-62: Generating the dynamic angle offset

With infinitely turning axes module scaling must be set in **S-0-0076, Position data scaling type**.

**Note:** For a constantly fault-free processing of the cam hub, the hub and the infinitely turning axes and **S-0-0103, Modulo value** must have the same value.

**Selecting the active cam table**

The active cam table (P-0-0072 or P-0-0092) is selected with parameters **P-0-0088, Cam shaft control** and **P-0-0094, Cam shaft switch angle**. The active cam is in **P-0-0089, Cam shaft status**. A transition is started by changing the control word. It is conducted and acknowledged by the drive in the status word if the table accessing angle traverses the cam transition angle.

**Changing the cam hub**

Parameter **P-0-0144, Cam shaft distance switch angle** is fixed at which the table access angle and thus a table element becomes effective for the cam hub. This means that an absolute position reference can be retained with a change.

The drive-guided dynamic synchronization is active in this mode as with "angle synchronization".

After the second synchronization step (absolute position matching) it applies: **S-0-0047** = XSynch + **S-0-0048**

The following illustrates how the command value is generated with the above formula.

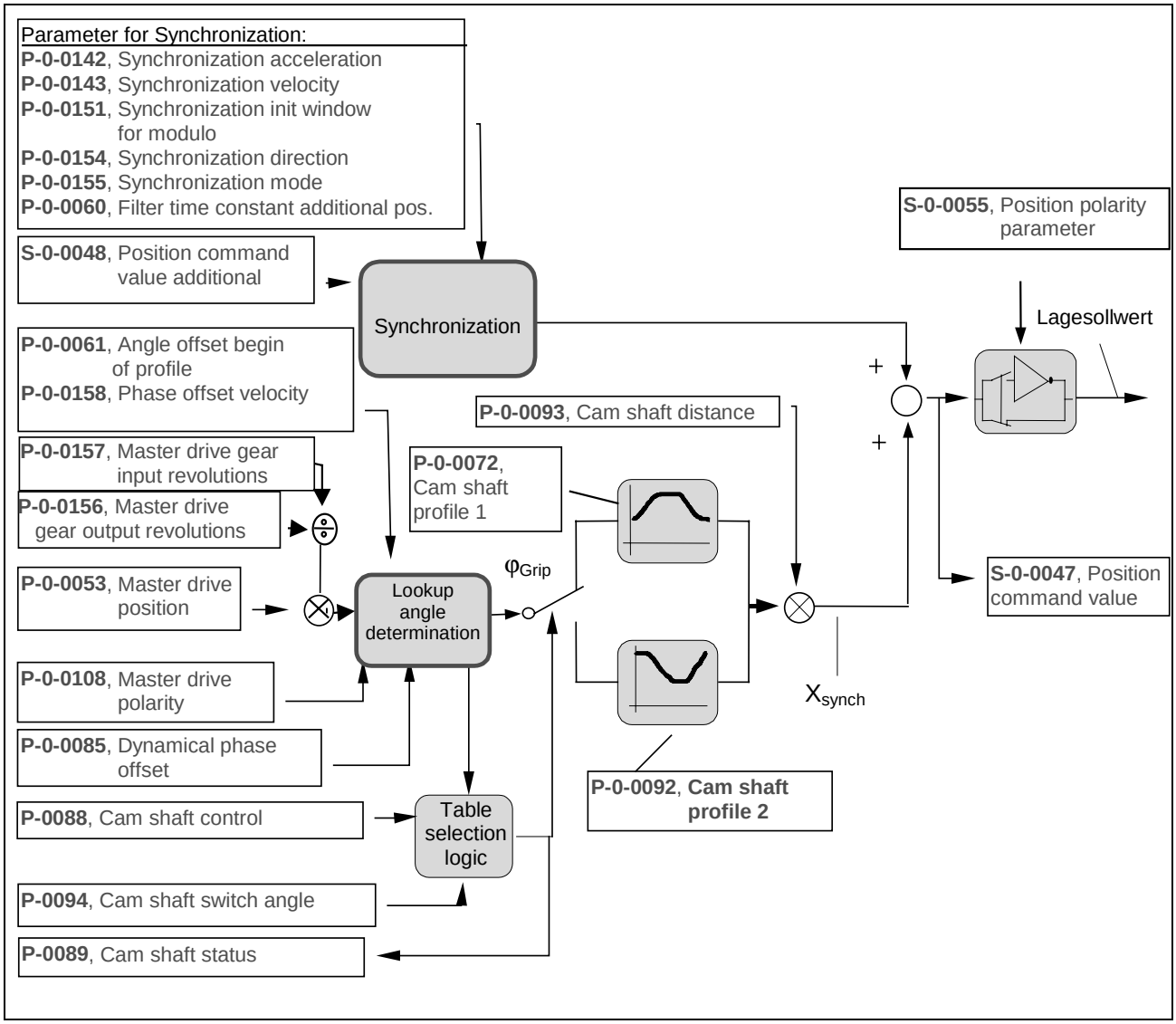



Fig. 8-63: Command value preparation for electronic cams

# 8.15 Operating mode: electronic cam shaft with real master axis

There is a fixed relationship between master axis position and following axis in operating mode electronic cam with real master axis.

The (real) master axis position is determined from the master axis encoder evaluation.

The structure of the mode "Electronic cam with real master axis" is illustrated below:

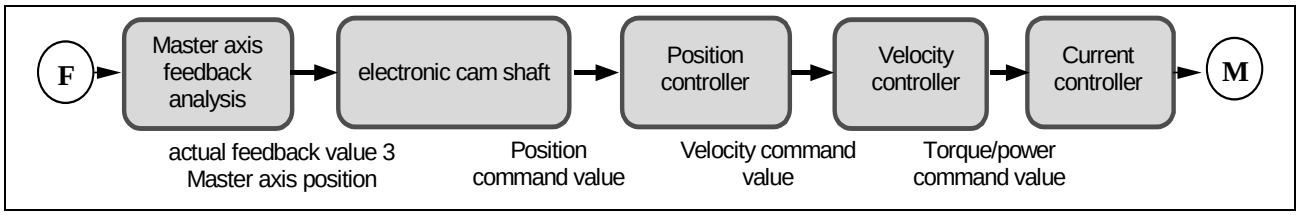



Fig. 8-64: Electronic cam shaft Block Diagram

## Pertinent Parameters

The parameters listed in the sections on "Operating mode: electronic cam shaft with virtual master axis" and "Master Axis Feedback Analysis" are involved in this operating mode.

## Functional Principle

Operating mode electronic cam with real master axis combines the modes "Electronic cam with virtual master axis" and the "Master axis encoder evaluation". **P-0-0052, Position feedback value 3** determined by master axis encoder evaluation is copied into parameter **P-0-0053, Master drive position**.

The function of the individual blocks is outlined in the relevant sections.

see section: "Master Axis Feedback Analysis"

see section: "Operating mode: electronic cam shaft with virtual master axis"

see section: "Position Controller"

see section: "Velocity Controller"

see section: "Current Controller"

**Note:** As long as the master axis encoder is not referenced (position status bit 2 = 0) the drive follows the master axis position with synchronous speed. The dynamic synchronization is begun as soon as the master axis encoder has been absolutely evaluated (referenced) and synchronous speed has been reached.

During dynamic synchronization the path is lengthened by the position jump of the master axis encoder position when detecting the zero pulse.

Path = XSynch + **S-0-0048** - **S-0-0047 +(P-0-0052[n]-P-0-0052[n-1])**

XSynch: synchronous position command value

Fig. 8-65: Traversing path to absolute synchronization

It applies:

P-0-0052[n] = P-0-0053[n] = Position of the master axis encoder directly after detecting the zero pulse.

P-0-0052[n-1] = P-0-0053[n-1] = Position of the master axis encoder indirectly after detecting the zero pulse.

# 9 Basic Drive Functions

## 9.1 Physical Values Display Format

Data exchange between the controller and the primary control system or user interface occurs by reading and writing controller parameters. Information about the unit and the number of decimal places (see also "Parameter") is necessary for interpreting the operating data of a parameter. The value of the operating data is produced from these data.

The following illustration shows this with an example.

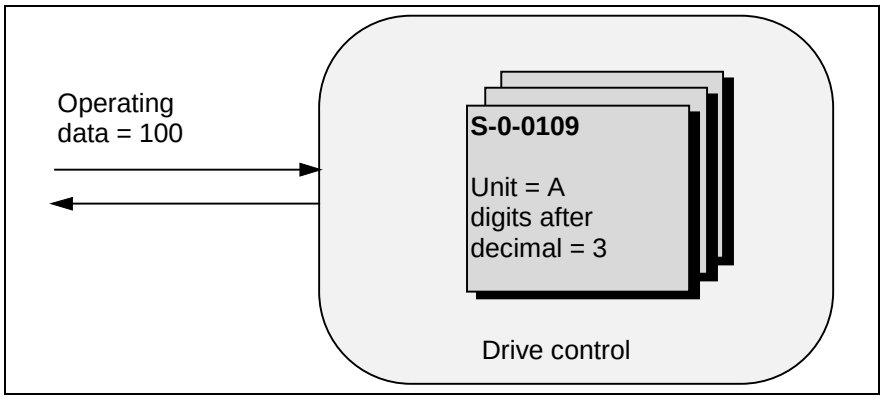



Fig. 9-1: Example for interpreting operating data in the drive

*The combination of unit and number of decimal places is expressed with the term scaling.*

The operating data of the parameter S-0-0109 is given the value 100 in the picture shown above. When combined, the unit A (ampere) that belongs to this parameter and the number of decimal places produce the physical value **0.100 A**.

Each parameter can therefore be called up with a unit and the number of decimal places. The combination of these two criteria is united under the term **scaling**. When interpreting operating data, these must always be included in the analysis. Units and number of decimal places are listed along with all other parameter attributes in the Parameter Description.

### Adjustable Scaling for Position, Velocity, and Acceleration Data

**The value of position, velocity, and acceleration data can be set by adjustable scaling.**

The parameter scaling for

- position,
- velocity and
- acceleration data

can be adjusted. It can be set by the user with scaling parameters. It enables

- the value of this data to be made compatible for exchange between control system and control drive, or, in other words, the data can be exchanged in the control system's internal format. The control system will not need to convert this data.
- this data to conform to machine kinematics. Linear movements can be described with linear units, for example, and rotary movements can be described with rotary units.

It is possible to select between linear and rotary scaling, and preferred and parameter scaling, as well as between motor and load reference.

## Linear - Rotary Scaling

Adjustable scaling allows either linear or rotary scaling to be selected. Linear motors normally use a linear scale. Rotary motors use either a rotary or linear scale if their rotary movement is converted into a linear movement (with a ballscrew, for example).

## Preferred Scaling - Parameter Scaling

Adjustable scaling allows either preferred scaling or parameter scaling to be selected. If preferred scaling is selected, the appropriate scaling factor parameters and scaling exponent parameters in **S-0-0128, C200 Communication phase 4 transition check** are overwritten with preferred values. This sets a pre-defined scaling. The scaling factor parameter and the scaling exponent parameter are not entered. The preferred scaling adjusts itself to the selection of linear or rotary scaling.

The following preferred scalings are available:

| Physical Value: | Rotary Preferred Scaling: | Linear Preferred Scaling (mm): | Linear Preferred Scaling (Inch): |
|---|---|---|---|
| Position data | 0.0001 Degrees | 0.0001 mm | 0.001 Inches |
| Velocity Data | 0.0001 RPM, or 10^-6 Rev/s | 10^-6 m/min | 10^-5 in/min |
| Acceleration Data | 0.001 rad/s² | 10^-6 m/s² | -- |

Fig. 9-2: Preferred scaling

## Motor Reference - Load Reference

Either motor reference or load reference can be selected when adjusting the scaling.

With rotary load reference, the scaled data from the motor format is converted to the transmission output format with the transmission ratio **S-0-0122, Output revolutions of load gear** / **S-0-0121, Input revolutions of load gear**.

**load reference**

With linear load reference, the scaled data from the motor format is converted to feed constant format with the transmission ratio **S-0-0122, Output revolutions of load gear** / **S-0-0121, Input revolutions of load gear** and the feed constant **S-0-0123, Feed constant**.

The following restrictions apply in relationship to the motor type being used :

- Rotary motor reference cannot be set with linear motors.
- Linear motor reference cannot be set with rotary motors.

# Display Format of Position Data

The scaling of drive controller position data is adjustable. This is done with the parameters

- **S-0-0076, Position Data Scaling Type**
- **S-0-0077, Linear Position Data Scaling Factor**
- **S-0-0078, Linear Position Data Scaling Exponent**
- **S-0-0079, Rotational position resolution**

This differentiates between linear and rotary scaling. **S-0-0079, Rotational position resolution** sets the rotary position scaling. **S-0-0077, Linear Position Data Scaling Factor** and **S-0-0078, Linear Position Data Scaling Exponent** set the linear position scaling.

The scaling type is set in **S-0-0076, Position Data Scaling Type**.

The parameter is defined as follows:

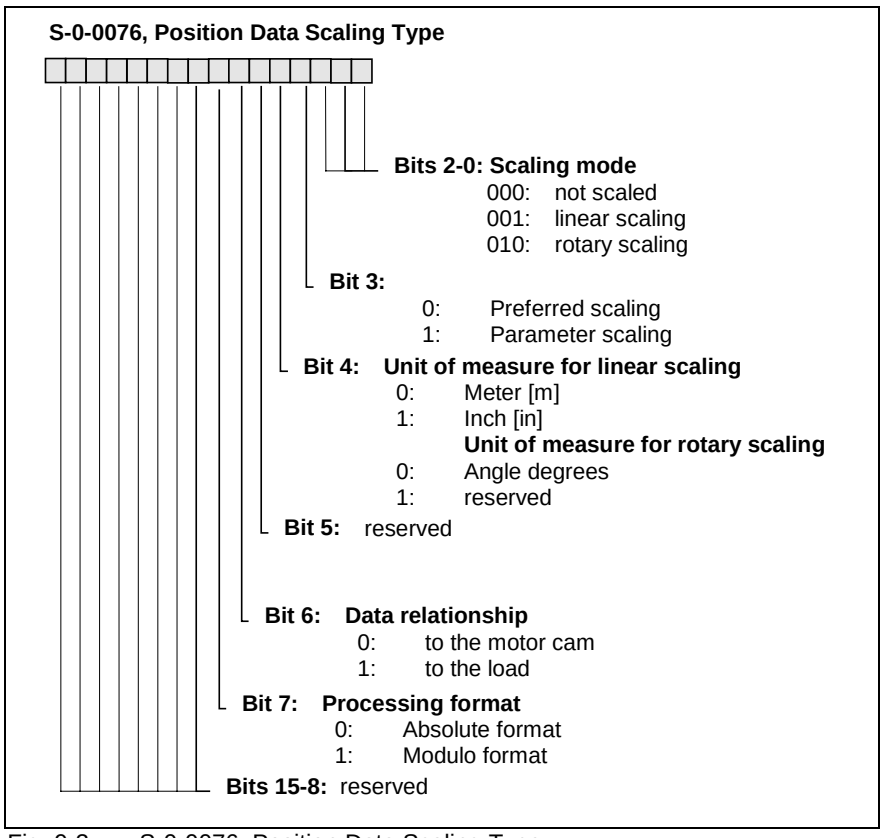



Fig. 9-3: S-0-0076, Position Data Scaling Type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check**, and the command error message **C213 Position Data Scaling Error** is generated, if necessary.

## Velocity Data Display Format

The scaling of the drive controller's velocity data is adjustable.

This is done with the parameters

- **S-0-0044, Velocity data scaling type**
- **S-0-0045, Velocity data scaling factor**
- **S-0-0046, Velocity data scaling exponent**

The scaling type is set in **S-0-0044, Velocity data scaling type**.

The parameter is defined as follows:

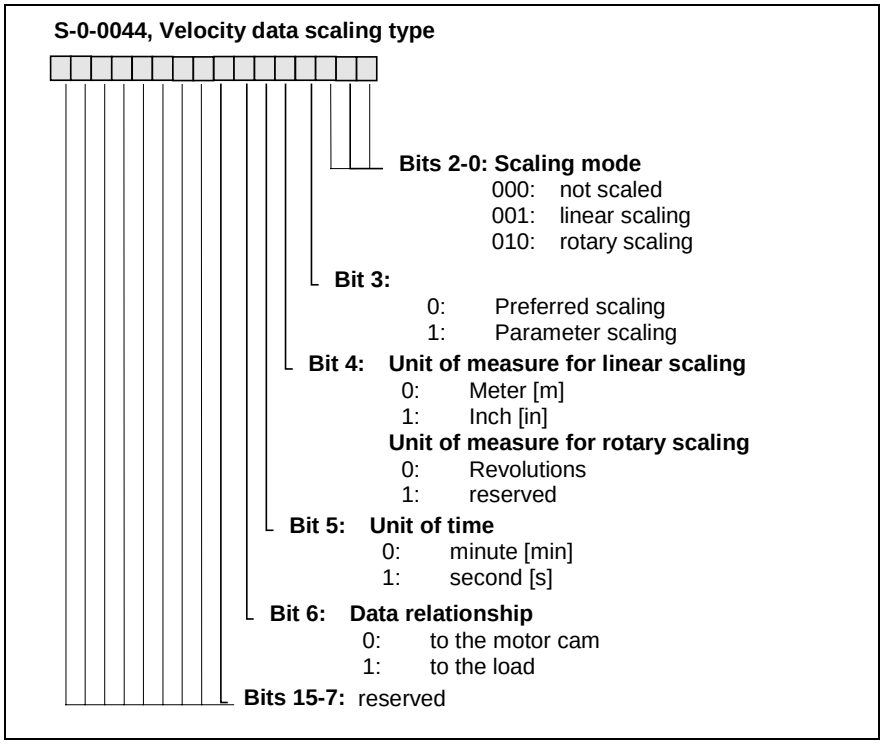



Fig. 9-4: S-0-0044, Velocity data scaling type

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check,** and the command error message **C214 Velocity Data Scaling Error** is generated, if necessary.

## Acceleration Data Display Format

The scaling of the drive controller's acceleration data is adjustable.

This is done with the parameters

- **S-0-0160, Acceleration data scaling type**
- **S-0-0161, Acceleration data scaling factor**
- **S-0-0162, Acceleration data scaling exponent**

The scaling type is set in **S-0-0160, Acceleration data scaling type**. The parameter is defined as follows:

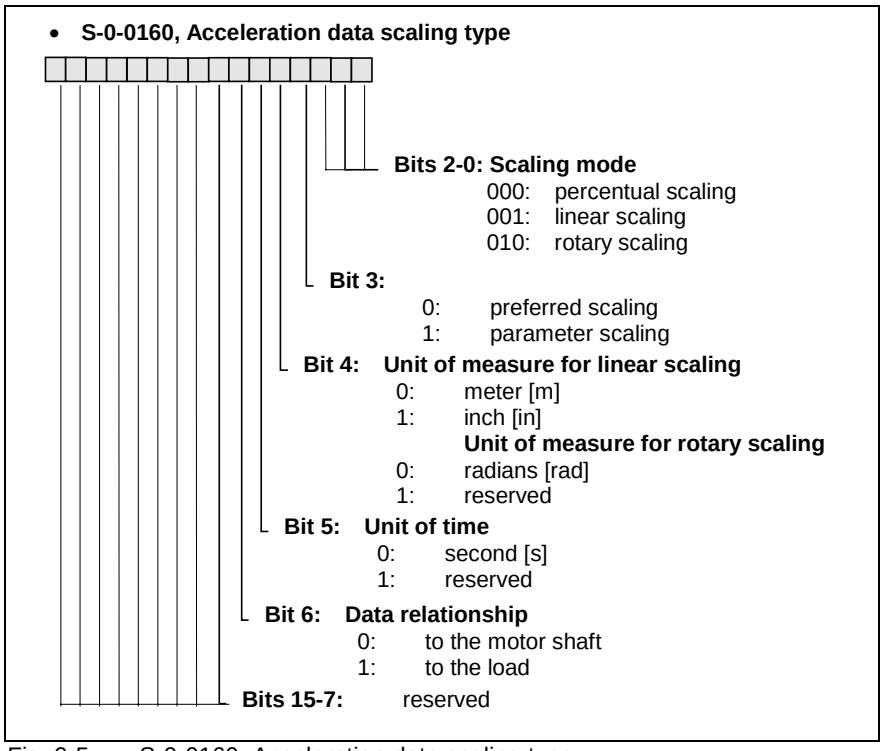



Fig. 9-5: S-0-0160, Acceleration data scaling type

The actual scaling type is set in bit 0..2.

The scaling type setting is checked for plausibility in **S-0-0128, C200 Communication phase 4 transition check,** and the command error message **C215 Acceleration Data Scaling Error** is generated, if necessary.

## Command Polarities and Actual Value Polarities

The drive-internal polarities of position, velocity, torque/force and actual value are fixed. The following applies:

| Motor type: | Drive internal positive direction definition: |
|---|---|
| Rotary motors | Clockwise rotation facing the motor shaft |
| Linear motors | Move in the direction of the connection of the power cable on the primary component |

Fig. 9-6: Drive internal positive direction definition

The positive direction is specified by the manufacturer for MHD-, MKD and MKE motors. Asynchronous motors, linear synchronous motors and MBS motors should be set in this direction during installation. (see "Other Motor Encoder Characteristics"). The command polarity and actual value polarity of the drive is thereby fixed.

If the motor definition of the positive direction does not conform to the requirements of the machine, the parameters

- **S-0-0055, Position Polarity Parameter**
- **S-0-0043, Velocity polarity parameter**
- **S-0-0085, Torque/Force polarity parameter**

can invert the command and actual value polarities.

**Note:** If the polarity needs to be changed, all 3 parameters should always be inverted at the same time, so that the polarities of the position, velocity and torque have the same sign.

The following illustration shows the operating characteristics of the polarity parameters.

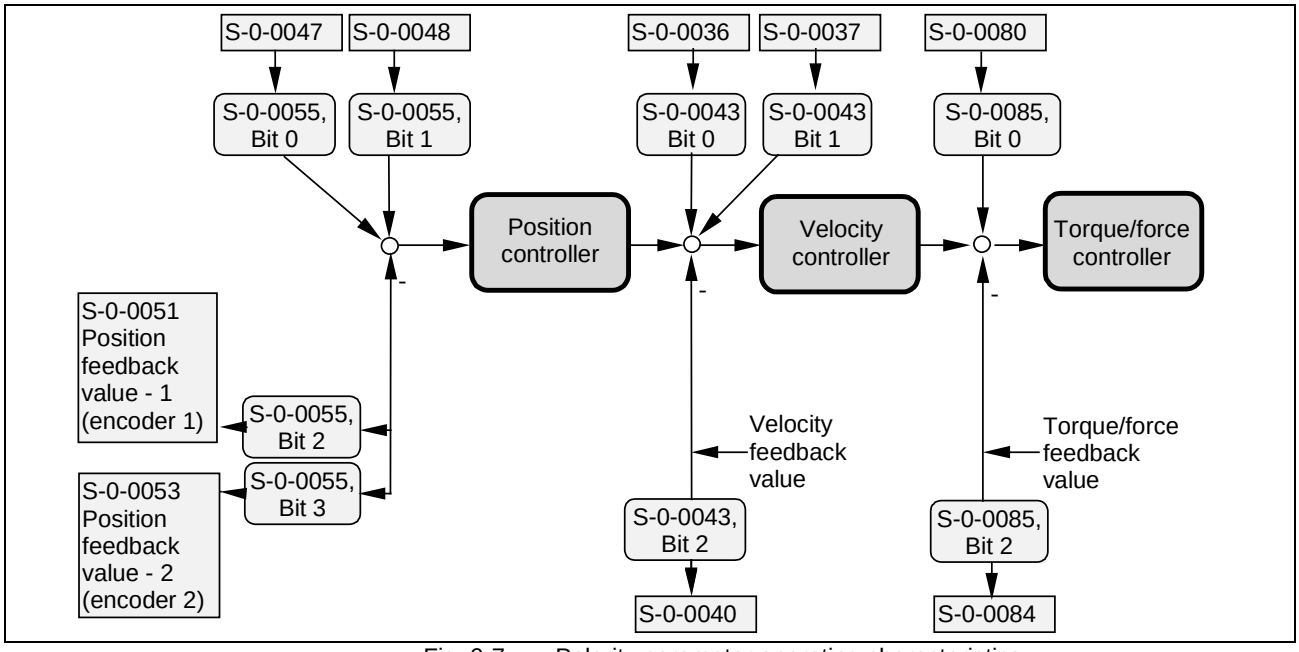



Fig. 9-7: Polarity parameter operating characteristics

The polarity parameters affect only the display values, not the control feedback values.

The drive software only allows all bits within a polarity parameter to be inverted. If bit 0 is inverted, all other bits of the parameter are also inverted. This protects against the danger of adding positive feedback into the control loop (command and feedback values with opposing polarities) due to incorrectly set command and feedback value polarities.

## Mechanical Transmission Elements

Mechanical transmission elements are gearboxes and feed mechanisms between the motor shaft and the load. Entering this data is necessary for the load to convert the position, velocity, and acceleration physical values, if these are scaled for the load.

(See also "Adjustable Scaling for Position, Velocity, and Acceleration Data".)

To see if this parameter has been entered correctly, move the shaft and compare the path followed with the position feedback value and the path actually taken.

### Transmission Ratio

The transmission ratio can be set with the parameters

- **S-0-0121, Input revolutions of load gear**
- **S-0-0122, Output revolutions of load gear**

The ratio between transmission input and transmission output is parameterized here.

**Example:**

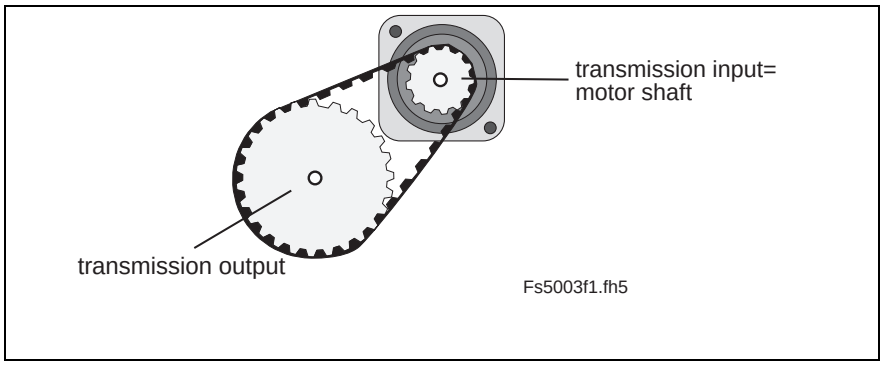



Fig. 9-8: Transmission ratio parameterization

In the illustration above, 2 transmission input revolutions ( = motor revolutions) were equivalent to 1 transmission output revolutions. The proper parameterization for this would be :

**S-0-0121, Input revolutions of load gear** = 2

**S-0-0122, Output revolutions of load gear** = 1

## Feed Constant

The feed constant defines how far the load moves linearly per transmission output revolution. It is specified in the parameter **S-0-0123, Feed constant**.

The value programmed here is used along with the transmission ratio for converting the position, velocity, and acceleration data from motor reference to load reference.

**Example:**

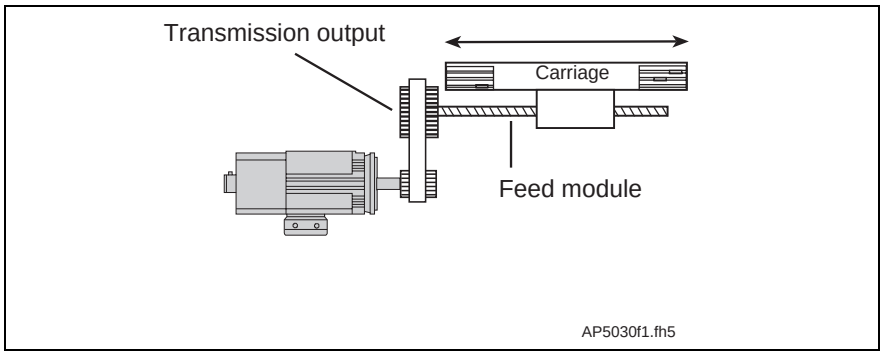



Fig. 9-9: Feed constant parameterization

Example:

In the illustration above, the feed module would cover 10 mm per transmission output revolution. The proper parameterization for this would be:

S-0-0123, Feed Constant = 10 mm/Rev

# Modulo Feature

When the modulo function is activated, all position data are displayed in the range 0... (modulo value). Thus it is possible to implement an axis which can move infinitely in one direction. There is no overrunning of the position data.

The modulo value is set with the parameter **S-0-0103, Modulo Value**.

The modulo function is activated by the parameter **S-0-0076, Position Data Scaling Type**.

(See also "Display Format of Position Data".)

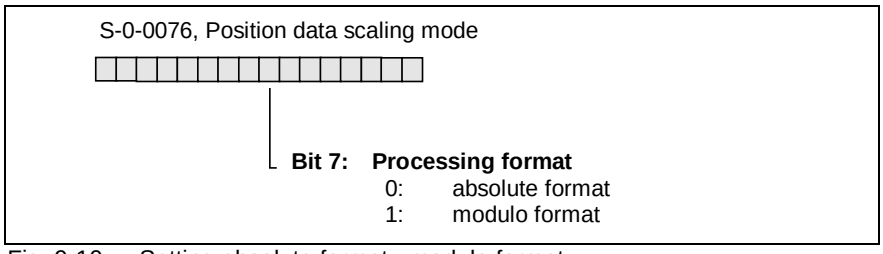



Fig. 9-10: Setting absolute format - modulo format

**Note:** Modulo processing of position data is only allowed with rotary motor types. This is checked in **S-0-0128, C200 Communication phase 4 transition check** and generates the command error **C213 Position Data Scaling Error** if necessary.

The following illustration shows the difference in displaying the position data in absolute format and modulo format:

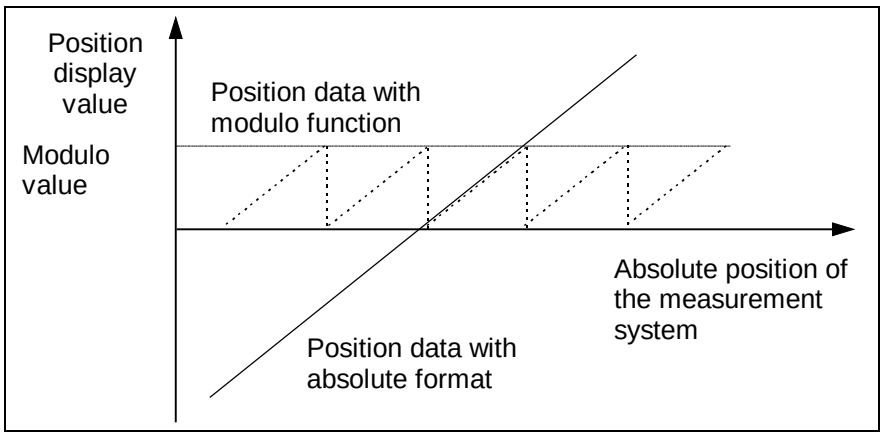

Position display value
Modulo value
Position data with modulo function
Absolute position of the measurement system
Position data with absolute format

Fig. 9-11: Display value of positions in absolute format and modulo format

## Modulo Processing-Limiting Conditions

If modulo processing of position data is selected, in connection with

- the active operating mode and
- the selected position scaling

the following limiting conditions for error-free processing of the position data must be observed.

The limiting conditions are as follows:

- The modulo range **S-0-0103, Modulo Value** may not be greater than the maximum travel range.
- If rotary or linear position scaling with load reference and without angle synchronization is used as the operating mode, the product of **S-0-0103, Modulo Value, S-0-0116, Resolution of motor feedback** and **S-0-0121, Input revolutions of load gear** must be smaller than 2^63.

If, in addition to this, an external measurement system is used, the additional requirements are:

- If rotary position scaling with motor reference and no angle synchronization operating mode is used, the product of **S-0-0103, Modulo Value**, **S-0-0117**, **Feedback 2 Resolution** and **S-0-0122, Output revolutions of load gear** must be smaller than 2^63.

Compliance with the limiting conditions is checked in **S-0-0128, C200 Communication phase 4 transition check**, and the command is terminated with the error **C227 Modulo Range Error** if necessary.

## Processing Command Values in Modulo Format, Shortest Path - Direction Selection

The interpretation of position command values such as **S-0-0047, Position Command Value** and **S-0-0258, Target Position** when the modulo function has been activated is dependent on the selected mode.

The following possibilities exist:

- Shortest Path
- Positive Direction
- Negative Direction

Parameter **S-0-0393, Command value mode** is used to set the mode. This parameter is effective only if modulo format has been activated in **S-0-0076, Position data scaling type**.

The following settings can be entered:

**S-0-0393 = 0** **Modulo Mode "Shortest Path"**

The next command value is reached with the shortest path. If the difference between two successive command values is greater than half of the modulo value, the drive moves toward the command value in the opposite direction.

**S-0-0393 = 1** **Modulo Mode "Positive Direction"**

The command value is always approached in a positive direction, regardless of whether or not the difference between two successive command values is greater than half of the modulo value.

**S-0-0393 = 2** **Modulo Mode "Negative Direction"**

The command value is always approached in a negative direction, regardless of whether or not the difference between two successive command values is greater than half of the modulo value.

# 9.2 Setting the Measurement System

The drive controller is equipped with two permanently installed encoder interfaces, i.e., X4 and X8.

The encoder interface 1 (X4) is designed so that the following encoder types can be evaluated:

**Encoder interface 1:**

- digital servo feedback (DSF, HSF)
- resolver
- resolver without feedback data memory

Using encoder interface 2 (X8) it is possible to evaluate the following encoder types:

**Encoder interface 2:**

- incremental encoder with sine signals 1Vss
- incremental encoder with square-wave signals (TTL)
- measuring system with EnDat interface
- gearwheel encoder with 1Vss signals

Both encoder interfaces can be used to connect either a motor or an optional encoder.

At which interface the motor encoder should be connected and what type it is set in parameter **P-0-0074, Feedback type 1.**

If an optional encoder is also to be used, the parameter **P-0-0075, Feedback type 2** must be used to define encoder interface and encoder type.

The following table explains the relationship:

| **Measuring system type:** | **Interface** | **Value in P-0-0074/75** |
|---|---|---|
| digital servo feedback or resolver | 1 | 1 |
| incremental encoder with sine signals from Heidenhain with 1V signals | 2 | 2 |
| Incremental encoder with square wave signals from Heidenhain | 2 | 5 |
| Encoder with EnDat-interface | 2 | 8 |
| gearwheel encoder with 1Vss signals | 2 | 9 |
| Resolver without feedback data storage | 1 | 10 |
| Resolver without feedback data storage + incremental encoder with sine signals | 1 + 2 | 11 |
| Hall encoder + square wave encoder | 1 + 2 | 12 |
| Hall encoder plus sinus encoder | 1 + 2 | 14 |

Fig. 9-12: Measuring systems - connections

The table illustrates that some combinations are not possible as each encoder interface is only physically present once.

To display the actual position value of the individual measuring systems, use parameters:

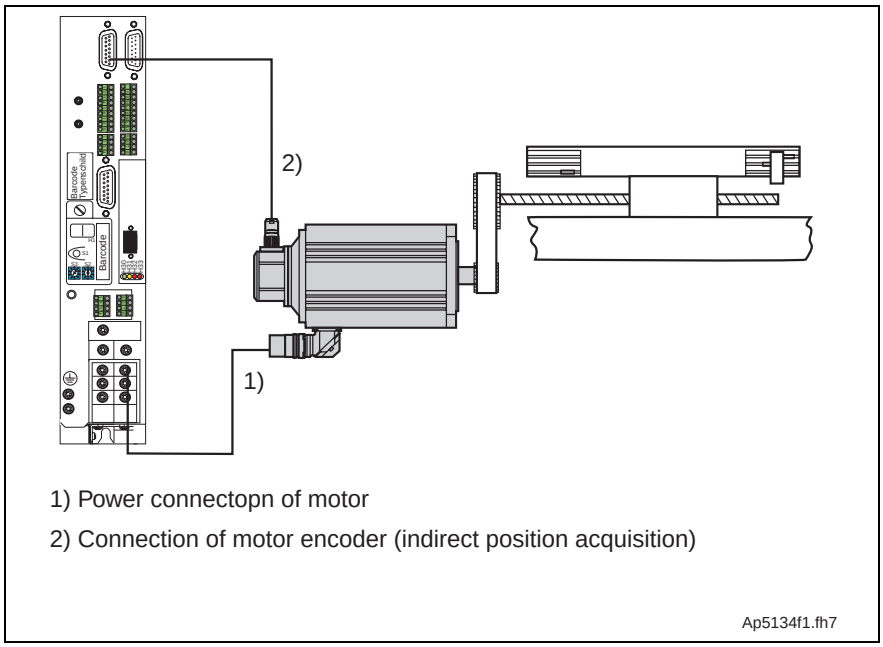
- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**

To set the absolute reference of actual position value 1/2 to the machine zero point, use commands

- **S-0-0148, C600 Drive controlled homing procedure command or**
- **P-0-0012, C300 Command 'Set absolute measurement'**

## Motor Encoder

The measurement system which is directly coupled with the motor shaft without a gearbox between them is called the motor encoder. As the motor is usually coupled to the load with a mechanical gearbox and possibly a feed unit, this is an indirect measurement system. If a second measurement system is attached directly to the load, than this direct measurement system (see "Optional encoder"). Hereafter, are shown typical applications of indirect distance measuring.

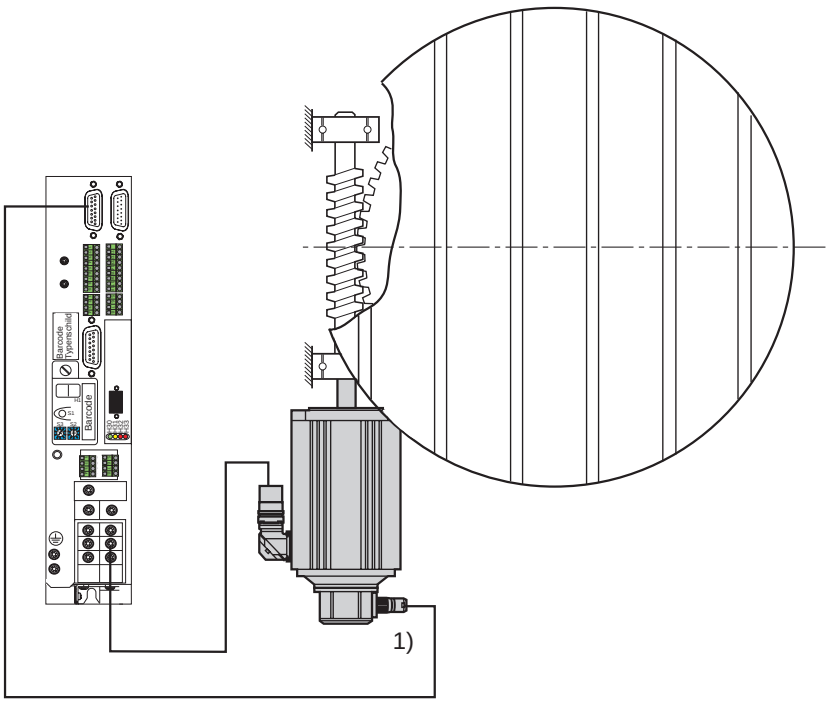



1) Power connectopn of motor

2) Connection of motor encoder (indirect position acquisition)

Ap5134f1.fh7

Fig. 9-13: Application: Motor encoder with linear servo axis




1) Indirect position acquisition with internal encoder

Ap5135f1.fh7

Fig. 9-14: Application: Motor encoder with rotary servo axis

The following parameters

- **P-0-0074, Feedback type 1**
- **S-0-0116, Feedback 1 Resolution**
- **S-0-0277, Position feedback 1 type**

are used to parameterize the motor feedback. These specify the interface number to which the measurement system is connected, the motor feedback resolution, as well as the direction of movement, etc. The parameter **S-0-0051, Position feedback 1 value** displays the position of the motor feedback.

The absolute measurement relative to the machine zero point is set with

- **S-0-0148, C600 Drive controlled homing procedure command**

or, for absolute encoders,

- **P-0-0012, C300 Command 'Set absolute Measurement'**

---

**Note:** For Rexroth Indramat MHD, MKD and MKE motors (with housings) all motor specific data is set-up automatically; no further user intervention is required for the installation of these motors.

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## Determining the Feedback Interface of the Motor Feedback

The encoder interface of the motor encoder is determined by the parameter **P-0-0074, Feedback type 1**. The number of the motor encoder type must be entered. The motor encoder interface in P-0-0074 is automatically set in some motor types.

(See also chapter: "Characteristics of the Different Motor Types".)

The following measurement systems and modules may be used with motors with motor encoder interfaces that can be parameterized.

| Measuring system: | Encoder interface | Value in P-0-0074 | For synchronous motors | For asynchronous motors |
|---|---|---|---|---|
| not available (only with rotary asynchronous motors) | - | 0 | no | yes |
| digital servo feedback (LSF,HSF) or resolver | 1 | 1 | yes | yes |
| Incremental encoder with sine signals from (1V signals) | 2 | 2 | yes | yes |
| Incremental encoder with square wave signals from Heidenhain | 2 | 5 | yes | yes |
| encoder with EnDat interface from Heidenhain | 2 | 8 | yes | yes |
| gearwheel encoder with 1Vss signals | 2 | 9 | no | yes |
| resolver without feedback data memory | 1 | 10 | yes | no |
| resolver without feedback data memory plus incremental encoder with sine signals | 1 + 2 | 11 | yes | no |
| Hall encoder plus square wave encoder | 1 + 2 | 12 | yes | no |
| Hall encoder plus sinus encoder | 1 + 2 | 14 | yes | no |

Fig. 9-15: Determining encoder interface for the motor encoder

**Note:** The motor encoder is only then unnecessary if you work with a loadside motor encoder. This is only possible with rotary asynchronous motors (**P-0-4014, Motor type** = 2 or 6). In this case, the external encoder is the only control encoder (see also "Optional encoder").

## Motor Encoder Resolution

The motor encoder resolution is parameterized in the parameter **S-0-0116, Feedback 1 Resolution**. Enter the graduation scale of the motor feedback. If using a measurement system with intrinsic feedback data storage, the resolution will be taken from this and does not need to be entered.

Measurement systems with feedback storage:

- DSF, HSF
- Resolver
- EnDat

Depending on whether a rotary or linear motor is used, the units and the number of decimal places are changed via **S-0-0116, Feedback 1 Resolution**.

(see also chapter: "Linear-Rotational")

### Other Motor Encoder Characteristics

To parameterize the other motor encoder characteristics, use **S-0-0277, Position feedback 1 type**.

The structure of this parameter is as follows:

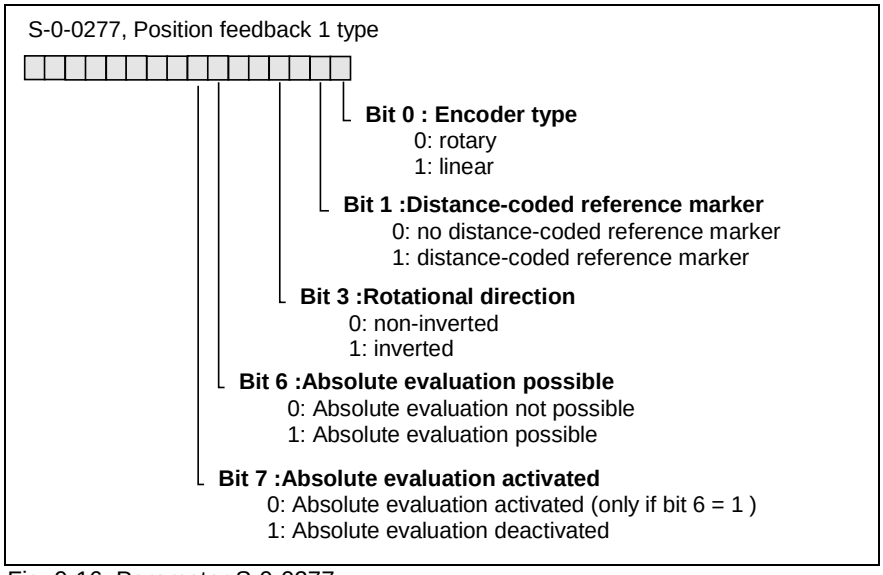

S-0-0277, Position feedback 1 type
Bit 0 : Encoder type
0: rotary
1: linear
Bit 1 :Distance-coded reference marker
0: no distance-coded reference marker
1: distance-coded reference marker
Bit 3 :Rotational direction
0: non-inverted
1: inverted
Bit 6 :Absolute evaluation possible
0: Absolute evaluation not possible
1: Absolute evaluation possible
Bit 7 :Absolute evaluation activated
0: Absolute evaluation activated (only if bit 6 = 1 )
1: Absolute evaluation deactivated

Fig. 9-16: Parameter S-0-0277

**Note:** The bits in the position encoder type parameter are partially set or deleted by the drive itself.

There are following criterias:

- If the connected motor has a motor feedback memory (MHD, MKD or MKE), then bits 0, 1 and 3 are cleared.
- If the connected motor is a linear motor, then bit 0 is set to 1.
- Depending on the absolute encoder range and the maximum travel range or modulo value, bit 6 is either set or cleared.

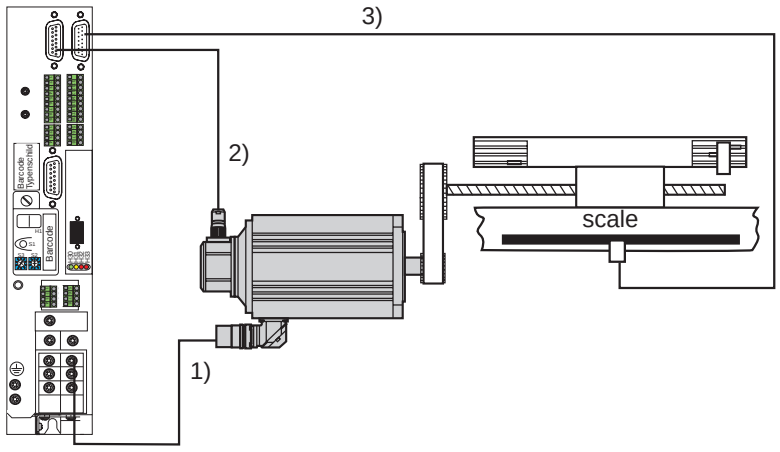
(See also chapter: "Supplementary Settings for Absolute Measuring Systems".)

## Optional encoder

A control with a direct measuring system facilitates higher contour precision of the machined workpieces in terms that it offers higher positioning accuracy. With setting the operation mode, you can determine that the position control in the drive is done with the position feedback of the optional encoder. Additionally, the velocity control can be completely or partially done with the velocity feedback signal of this measurement system.

(See also sections: "Operating Modes" and "Setting the Velocity Mix Factor".)

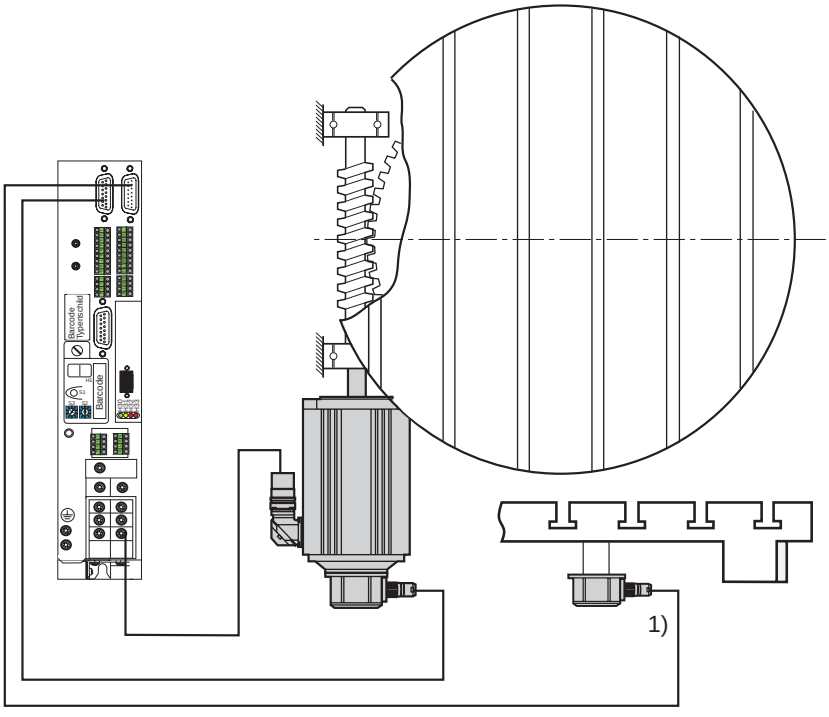
Typical application examples are shown in the following two pictures:




1) Power connectopn of motor
2) Connection of motor encoder
3) Connection of optional encoder (direct positon acquisition)

Ap5133f1.fh7

Fig. 9-17: Application: Optional encoder by linear servo axis




1) Direct position acquisition with external encoder

Ap5136 f1.fh7

Fig. 9-18: Application: Optional encoder by rotary servo axis

The optional encoder is parameterized with the

- **P-0-0075, Feedback type 2**
- **S-0-0117, Feedback 2 Resolution**
- **S-0-0115, Position feedback 2 type**
- **P-0-0185, Function of encoder 2**

parameters.

These specify:

- the feedback type which is used,
- the resolution of the optional encoder,
- the direction of movement, etc.

The parameter **S-0-0053, Position feedback 2 value** displays the position of the optional encoder.

Set the reference measure to the machine zero point as follows:

- **S-0-0148, C600 Drive controlled homing procedure command**

or, for absolute encoders,

- **P-0-0012, C300 Command 'Set absolute measurement'**

The optional encoder can be used for different purposes.

The evaluation mode for the optional encoder is set in parameter **P-0-0185, Function of encoder 2**.

| Value in P-0-0185, Function of encoder 2 | Meaning |
|---|---|
| 0 | Optional encoder as an additional load-side control encoder for position and/or velocity control loops. Signal frequency monitored for exceeding mximum frequency of the interface. Upon exceeding this, error **F246 Max signal frequency for encoder 2 exceeded** is generated and the position status (S-0-0403) cleared. |
| 1 | Optional encoder used as lead drive feedback |
| 2 | Optional encoder as only load-side control encoder (only with rotary asynchronous motors). In this case, there is no other motor encoder (P-0-0074 = "0"). Parameter P-0-0121, Velocity mix factor Feedback 1 & 2 must be set to 100%. |
| 3 | Optional encoder as measuring wheel. |

Fig. 9-19: Function of the optional encoder

## Determining the Encoder Interface of the Optional Encoder

Determining the encoder interface of the optional encoder uses parameter **P-0-0075, Feedback type 2**. The number of the encoder type must be entered there. The following measuring systems and modules are permitted for the evaluation of the optional encoder.

| Measuring system: | Interface | Value in P-0-0075 |
|---|---|---|
| not available | -- | 0 |
| digital servo feedback | 1 | 1 |
| Incremental encoder with sine signals from Heidenhain with 1V signals | 2 | 2 |
| Incremental encoder with square wave signals from Heidenhain | 2 | 5 |
| encoder with EnDat interface | 2 | 8 |
| gearwheel encoder with 1Vss signals | 2 | 9 |

Fig. 9-20: Encoder interface of the optional encoder

If "0" is entered in **P-0-0075, Feedback type 2** as encoder type, then the encoder evaluation of the optional encoder is switched off.

## Optional Encoder Resolution

To parameterize the resolution of the optional encoder use the parameter **S-0-0117, Feedback 2 Resolution**.

This parameter indicates the number of lines of the optional encoder. If using a measurement system with intrinsic feedback data storage, the resolution will be taken from this and does not need to be entered.

Measurement systems with feedback storage are available if

- **DSF, HSF**
- **Encoder with EnDat-Interface**

is used as the optional encoder interface.

Depending on whether a rotary or linear measurement system was parameterized in bit 0 of **S-0-0115, Position feedback 2 type**, the unit and number of digits after the decimal is switched by **S-0-0117, Feedback 2 Resolution**.

Rotary: Cycles/Rev.

Linear: 0.00001 mm

## Actual Feedback Value Monitoring

In applications where an optional measurement system is used, the position feedback monitor can offer an additional margin of safety.

The actual position monitor compares **S-0-0051, Position feedback 1 value** and **S-0-0053, Position feedback 2 value** and is thus capable of diagnosing the following axis error:

- Slip in the drive mechanical system
- Measurement system errors (as far as this is not recognized by the other measurement system monitors)

To set the monitor function use the parameter

- **S-0-0391, Monitoring window feedback 2**

If an error occurs, the error message **F236 Excessive position feedback difference** is generated.

### Basic Operating Characteristics of the Position Feedback Monitor

The position feedback monitor compares the position feedback value of the encoder 1 with the encoder 2. If the deviation of both position values is greater than **S-0-0391, Monitoring window feedback 2**, the error **F236 Excessive position feedback difference** is generated. As a result, the motor and optional encoder home mark bits are cleared.

The position feedback value is only active if an optional encoder is available and evaluated and if **S-0-0391, Monitoring window feedback 2** is not parameterized with a 0.

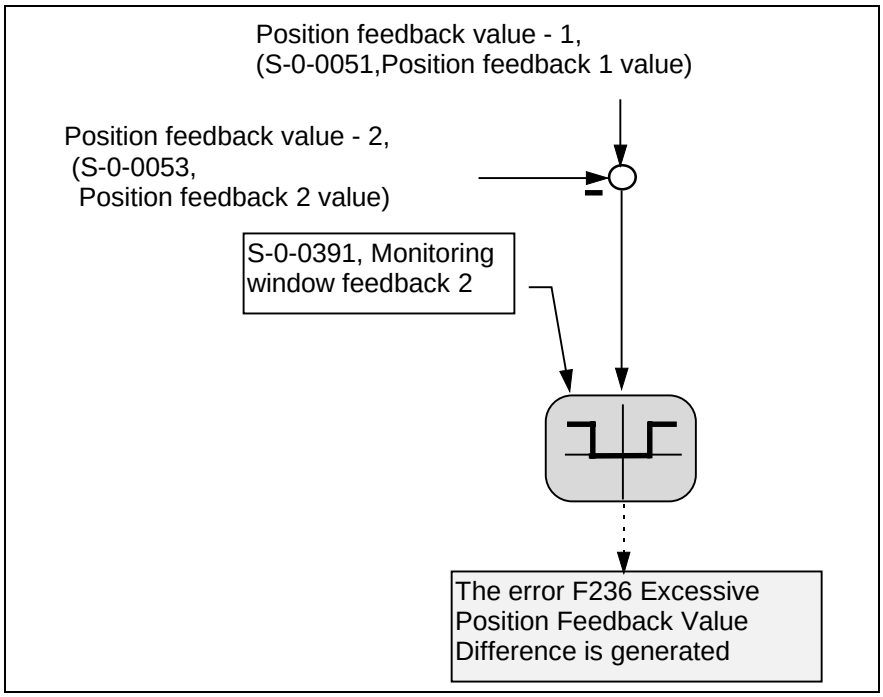

Position feedback value - 1,
(S-0-0051,Position feedback 1 value)
Position feedback value - 2,
(S-0-0053,
Position feedback 2 value)
S-0-0391, Monitoring window feedback 2
The error F236 Excessive Position Feedback Value Difference is generated

Fig. 9-21: Position feedback value monitoring schematic

**Setting the Position Feedback Monitoring Window**

The requirements for setting the position feedback value monitor are:

- All drive regulator loops must be set correctly.
- The axis mechanical system must be in its final form.
- The axis must be homed.

The monitoring window must be determined according to the application. The following basic procedure is recommended for doing this:

- Run a typical operating cycle. While doing this, set the planned acceleration and velocity data of the axis.
- Enter progressively smaller values in the parameter **S-0-0391, Monitoring window feedback 2** until the drive gives the error message **F236 Excessive position feedback difference**. Depending on the mechanical system, you should start with 1..2 mm and decrease the window in steps of 0.3 ... 0.5 mm.
- The value at which the monitor is triggered should be multiplied with a tolerance factor of 2 ... 3 and entered in parameter **S-0-0391, Monitoring window feedback 2**.

When determining the monitoring window, make sure that the position feedback monitor works dynamically. This means that even dynamic deviations of both position feedback values in acceleration and braking phases are registered. This is why it is not enough to use statical axis errors as the basis for the setting.

**Deactivating the Position Feedback Monitor**

It is possible to turn off the position feedback monitor in applications where the optionally connected measurement system does not control the axis position but is used for other measurements. To do this, enter 0 in the parameter **S-0-0391, Monitoring window feedback 2**.

### Other Optional Encoder Characteristics

To parameterize any other characteristics of the optional encoder, use **S-0-0115, Position feedback 2 type**

The structure of this parameter is as follows:

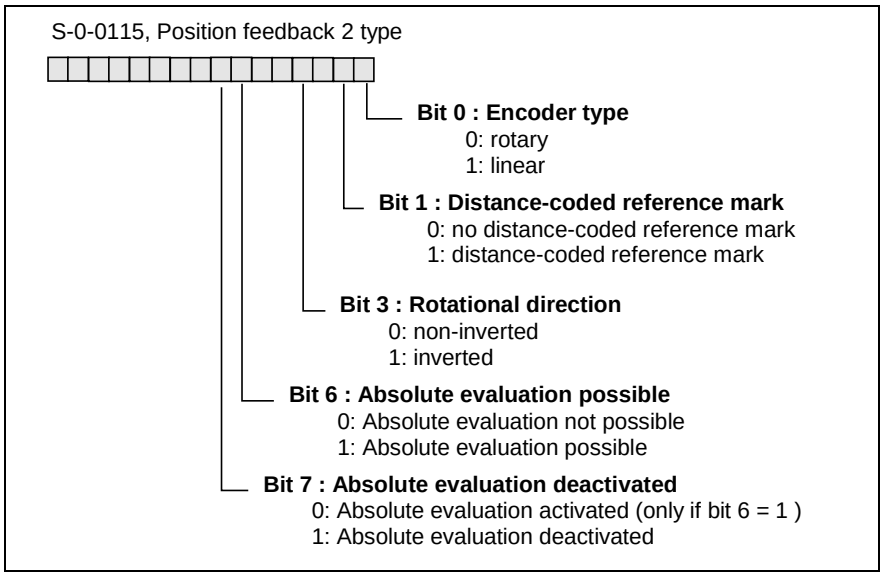

S-0-0115, Position feedback 2 type
Bit 0 : Encoder type
0: rotary
1: linear
Bit 1 : Distance-coded reference mark
0: no distance-coded reference mark
1: distance-coded reference mark
Bit 3 : Rotational direction
0: non-inverted
1: inverted
Bit 6 : Absolute evaluation possible
0: Absolute evaluation not possible
1: Absolute evaluation possible
Bit 7 : Absolute evaluation deactivated
0: Absolute evaluation activated (only if bit 6 = 1 )
1: Absolute evaluation deactivated

Fig. 9-22: Parameter S-0-0115

**Note:** The bits in the position encoder type parameter are partly set or cleared by the drive itself. There is following dependency:

- Depending on the absolute encoder range and the maximum travel range or modulo value, bit 6 is either set or cleared.(See also chapter: "Supplementary Settings for Absolute Measuring Systems".)

## Actual Feedback Values of Non-Absolute Measurement Systems After Initialization

If there is no absolute measuring system then the initialization value can be changed via parameter **P-0-0019, Position start value**.

**It hereby applies:**

If the parameter is write accessed in either phase 2 or 3 then this value is assumed as the initialization value:

| P-0-0019 written: | Position feedback value 1 | Position feedback value 2 |
|---|---|---|
| no | init. motor encoder value | init. motor encoder value |
| yes | position start value | position start value |

Fig. 9-23: Non-absolute measurement system position feedback values after initialization

**WARNING**

No valid position feedback values exist before the measurement system is initialized.
Initialization is performed during the transition check for communication phase 4.

Some measurement systems have limitations concerning the maximum velocity during their initialization.

| Measurement system | Maximum initialization velocity |
|---|---|
| DSF/HSF | 300 rpm |
| EnDat | Initialization should occur at standstill |
| Multiturn resolver | 300 rpm |

Fig. 9-24: Velocity allowed during initialization

## Drive-internal format of position data

There are two different formats in the drive used to display position data. We differentiate between

- display format and
- drive-internal format.

The display format defines the unit, i.e., the value with which the position data are exchanged between drive and control/surface. When a position data parameter is read, it is sent in the display format to the control. The display format is set with parameter **S-0-0076, Position Data Scaling Type**, **S-0-0077, Linear Position Data Scaling Factor**, **S-0-0078, Linear Position Data Scaling Exponent** and **S-0-0079, Rotational position resolution**. The control generally sets the format.

(See also "Physical Values Display Format".)

**The drive-internal position resolution depends on the travel range to be described**

The drive-internal format determines the value, the position command and feedback value editing as well as how the position control loop in the drive is performed. The drive uses the value of parameter **S-0-0278, Maximum travel range** to calculate the drive-internal format.

### Functional principle of the drive-internal position data formats

Position data processing in the drive has a constant data width from which the resolution of the position data to cover the travel range of the axis depends.

**Note:** The longer the distance to be represented, the smaller the drive-internal position resolution.

These parameter values are used to compute the **drive-internal resolution**:

- **S-0-0116, Feedback 1 Resolution** and
- **S-0-0256, Multiplication 1**.

The parameters for the encoder resolution are listed in the data sheets of the measuring system or they are automatically read out of the feedback memory if such a measuring system is present. The number of lines per encoder revolution or the grid constant of a linear scale (distance per division period) is set there. The parameter values for the multiplication are calculated by the drive during command **S-0-0128, C200 Communication phase 4 transition check**. They describe the resolution per division period (dp).

It thus applies for the drive-internal resolution:

for rotary motors:

$$\text{resolution} = \text{multiplication} * \text{encoder resolution}$$

| | |
|---|---|
| Resolution: | drive-internal resolution of position data [Incr/rev] |
| multiplication: | value in S-0-0256 or S-0-0257 [Incr/dp] |
| encoder resolution: | value in S-0-0116 or S-0-0117 [dp/Incr] |

Fig. 9-25: Drive-internal resolution of rotary motors

and for linear motors:

$$\text{resolution} = \frac{\text{multiplication}}{\text{encoder resolution}}$$

| | |
|---|---|
| Resolution: | drive-internal resolution of positon data [Incr/mm] |
| multiplication: | value in S-0-0256 or S-0-0257 [Incr/dp] |
| encoder resolution: | value in S-0-0116 or S-0-0117 [mm/dp] |

Fig. 9-26: Drive-internal resolution of linear motors

**Examples:**

1. MKD motor, S-0-0116 = 4, S-0-0256 = 32768, therefore: drive-internal resolution = 131072 increments/motor revolution or 0.00275 degrees/increment.
2. Linear scale as optional measuring system, S-0-0117 = 0.02 mm (grid division = 20µm), S-0-0257 = 32768, therefore: drive-internal resolution of approximately 1638400 increments/mm or 0.00061 µm (How to compute the drive-internal resolution if an optional encoder is used, is described in greater detail below).

**Note:** The value for the multiplication is limited to 4 .. 4194304 for technical reasons.

## Setting the drive-internal position data format

To set the drive-internal resolution, use the parameter **S-0-0278, Maximum travel range**.

**Setting the maximum travel range at start-up**

This parameter must be set at the time when an axis is commissioned to a value that equals at least the distance that the axis must travel. While executing the command **S-0-0128, C200 Communication phase 4 transition check,** the drive computes the values for **S-0-0256, Multiplication 1** and, if an optional measuring system is mounted, for **S-0-0257, Multiplication 2** as well. These parameters thus help to display the resolution.

**Multiplication is only reduced if the travel range can no longer be described**

The maximum possible resolution of the position feedback value of a position encoder for technical reasons equals 32768 increments per division period of the measuring system. This maximum resolution is only reduced if the travel range is set so large that it can no longer be described with the maximum resolution.

To compute the **multiplication**, the following calculations are conducted in the command **S-0-0128, C200 Communication phase 4 transition check**:

for rotary measuring systems:

$$\text{multiplication} = \frac{2^{31}}{\text{travelrange} \times \text{encoder\^{}re solution}}$$

| | |
|---|---|
| travel range: | travel range shown in encoder revolutions |
| multiplication: | value in S-0-0256 or S-0-0257 |
| encoder resolution: | value in S-0-0116 or S-0-0117 |

Fig. 9-27: Relationship between maximum travel range and multiplication with rotary measuring systems

**Examples:**

1. MHD motor with S-0-0116 = 512, maximum travel range 2048 motor revolutions, therefore, a multiplication of 2^31 / (2048 • 512) = 2048.
2. MHD motor with S-0-0116 = 512, maximum travel range 20 motor revolutions, therefore, a multiplication of 2^31 / (20 • 512) = 209715. The highest possible value equals 32768, thus a multiplication = 32768.

for <u>linear</u> scales:

$$\text{multiplication} = \frac{2^{31} \times \text{encoder resolution}}{\text{travel range}}$$

| | |
|---|---|
| travel range: | travel range shown in mm |
| multiplication: | value in S-0-0256 or S-0-0257 |
| encoder resolution: | value in S-0-0116 or S-0-0117 |

Fig. 9-28: Relationship between maximum travel range and multiplication in linear scales

**Example:**

1.) Linear scale with 0.02mm grid division, maximum travel range 5m, therefore a multiplication of 2^31 × 0.02 / 5000 = 8589 (→ 8192).

This results in a resolution of 0.02mm / 8192 = 0.002441 µm.

---

**Note:** When computing multiplication always use the next lower binary value of the precise results.

---

## Drive internal representation of position data when an optional encoder is present

**If an optional encoder is mounted, the multiplication of the motor encoder is guided by the optional encoder**

If there is an optional measuring system, then the multiplication of this encoder is computed as per the above formula in terms of the travel range set. The multiplication of the motor encoder is calculated so that it also covers this travel range. This means that values exceeding 32768 for the multiplication of the motor encoder can be generated depending on the mechanical transformation elements!

**Example:** MKD motor with rotary optional encoder

| | |
|---|---|
| motor encoder resolution | = 4 |
| optional encoder resolution | = 1000 |
| travel range | = 50 revolutions |
| gear ratio | = 1:1 |

1. Calculating the multiplication of the optional encoder:

2^31 / (1000 • 50) = 42949, technical maximum 32768, thus S-0-0257 = 32768.

This results in a resolution of 0.00001098 Degrees.

2. Calculating the multiplication of the motor encoder

2^31 / (4 • 50) = 10737418, the next smaller binary value = 8388608, thus S-0-0256 = 8388608. However, the technical maximum resolution is 4194304. Therefore, we set the value in S-0-0256 to 4194304. The resolution is 0.0002146 Degrees.

**The resolution can never exceed 4194304 • S-0-0116!**

**Example:** MHD motor with linear optional encoder

| | |
|---|---|
| Resolution of the motor encoder | = 256 |
| Resolution of the optional encoder | = 0.02 mm |
| Travel range | = 5 m |
| feed constant | = 10 mm |
| Gear transmission ratio | = 3:1 |

1. Calculating the multiplication of the optional encoder :

2^31 • 0.02mm / 5000mm = 8589

Technically reasonable is a maximum of 8192, therefore

S-0-0257 = 8192. This gives a resolution of 0.00244 µm.

2. Calculation of the Multiplication of the motor encoder:

5m of travel range give 500 gear output revolutions and therefore 1500 gear input revolutions (motor revolutions).

2^31 / (256 • 1500) = 5592, the nearest smaller binary value = 4096, therefore S-0-0256 = 4096.

This results in a resolution of 0.000343 Degrees referred to the motor shaft.

### Processing format of the drive-internal position command interpolator

In the drive-internal position command interpolator, the position command profile for the drive-controlled travel commands such as drive halt, drive-controlled homing, operating mode drive-internal interpolation and so on are generated. The format of the drive-internal position data affect the maximum acceleration limit which can be pre-defined for the interpolator.

**The limits are not valid for cyclic command values, e.g. in operation mode Position control.**

The following relationships apply:

for rotary motors:

$$amax = \frac{51.471.854.040}{\text{encoder resolution} \times \text{multiplication}} \left[\frac{rad}{s^2}\right]$$

amax: maximum acceleration of position command of the interpolator
encoder resolution: value in S-0-0116
multiplication: value in S-0-0256

Fig. 9-29: Maximum acceleration of the position command interpolator as dependent on the drive-internal position data format

for linear motors:

$$amax = \frac{8.192.000.000 \times \text{encoder resolution}}{\text{multiplication}} \left[\frac{mm}{s^2}\right]$$

amax: maximum acceleration of position command of the interpolator
encoder resolution: value in S-0-0116 in mm
multiplication: value in S-0-0256

Fig. 9-30: Maximum acceleration of the position command interpolator as dependent on the drive-internal position data format

**Example**:

MHD motor with S-0-0116 = 512, multiplication = 32768, equalling a maximum acceleration of the position command interpolation of 3067 rad/s².

# 9.3 Supplementary Settings for Absolute Measuring Systems

## Encoder Types and Relevant Interfaces

The table below shows the absolute measuring systems, which can be used as motor encoder or optional encoder and the range which they can absolutely evaluate. The relevant encoder interface is also listed.

| Measuring system | Absolute encoder range | Interface (input no.): | as motor encoder: | as optional encoder: |
|---|---|---|---|---|
| Single/Multiturn-DSF/HSF | 1rev./4096rev. | Standard(1) | yes | yes |
| Single/Multiturn resolver | 1TP./65535TP. | Standard(1) | yes | no |
| Linear scale made by Heidenhain with EnDat interface | depends on encoder lengths | Optional(8) | yes | yes |
| Single/Multiturn rotary encoder made by Heidenhain with EnDat interface | 1rev./4096rev. | Optional(8) | yes | yes |

Fig. 9-31: Absolute measuring systems and their interfaces

# Absolute encoder range and absolute encoder evaluation

**Motor and/or optional encoders can be used as absolute encoders**

Measuring systems that supply absolute position information within one or several revolutions (single or multiturn encoder) or a within a specific traversing distance (absolute linear scales) can be used as motor and/or optional measuring systems.

The range (absolute encoder range), in which a measuring system can supply absolute position information, is stored in the data memory of the measuring system or the drive software.

---

**Note:** The absolute encoder range which the drive can evaluate can be limited with the use of **S-0-0278 Maximum travel range**. In parameters **S-0-0378 Absolute encoder range 1** or **S-0-0379 Absolute encoder range 2** the drive displays those absolute encoder ranges which can be evaluated.

---

Absolute measuring systems do not have to be homed after initialization of the drive firmware. The actual position value lies within the absolute encoder range, machine zero related, after initialization. It is only necessary to conduct a single set-up procedure (setting absolute dimension).

Whether a motor or an optional measuring system are to be evaluated as absolute encoders, depends on the following variables:

- the absolute encoder range (**S-0-0378, Absolute encoder 1, range / S-0-0379, Absolute encoder 2, range)** of the relevant encoder.
- the set position scaling (position data represented absolute or in modulo formats) in **S-0-0076, Position data scaling type**
- the travel range set in **S-0-0278, Maximum travel range** or
- the modulo value set in parameter **S-0-0103, Modulo value.**

Note the following relationships:

| Position scaling (Bit 6 of S-0-0076) | S-0-0278, Max. travel range | S-0-0103, Modulo value | Absolute encoder evaluation possible |
|---|---|---|---|
| Absolute format | < S-0-0378 / S-0-0379 | not relevant | yes |
| | > = S-0-0378 / S-0-0379 | not relevant | no |
| Modulo format | S-0-0103 | <= S-0-0378/S-0-0379 | yes |
| | S-0-0103 | > S-0-0378/S-0-0379 | no |

Fig. 9-32: Absolute encoder evaluation as depends on position format, modulo format and maximum travel range

The check whether a measuring system can be evaluated as an absolute system is conducted during command **S-0-0128, C200 Communication phase 4 transition check**. The results are displayed in bit 6 of the relevant position encoder type parameter (S-0-0277 / S-0-0115).

**Activating the absolute encoder evaluation**

If the absolute evaluation of a measuring system is possible but not wanted, this can be deselected in bit 7. The measuring system is then treated as if it were a non-absolute encoder.

The position encoder type parameter is structured as follows:

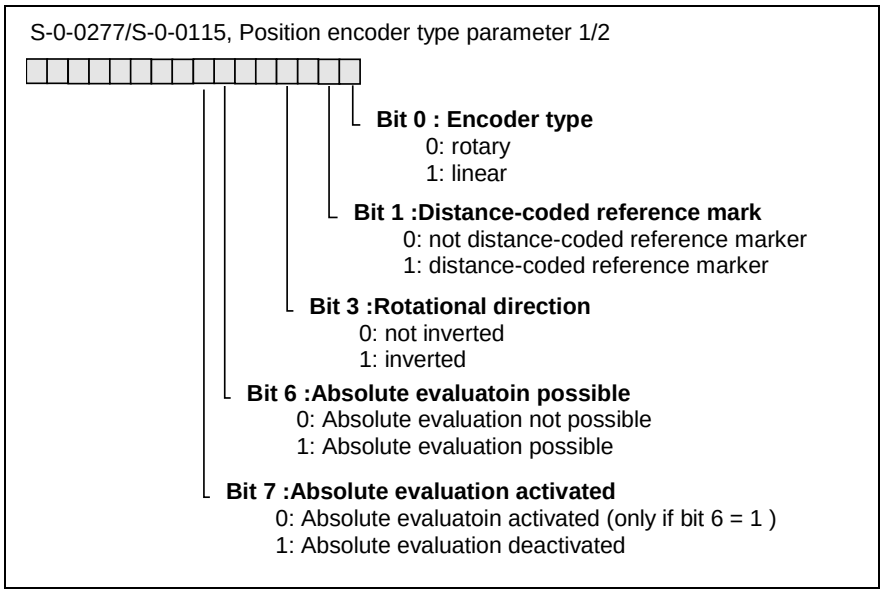

S-0-0277/S-0-0115, Position encoder type parameter 1/2
Bit 0 : Encoder type
0: rotary
1: linear
Bit 1 :Distance-coded reference mark
0: not distance-coded reference marker
1: distance-coded reference marker
Bit 3 :Rotational direction
0: not inverted
1: inverted
Bit 6 :Absolute evaluatoin possible
0: Absolute evaluation not possible
1: Absolute evaluation possible
Bit 7 :Absolute evaluation activated
0: Absolute evaluatoin activated (only if bit 6 = 1 )
1: Absolute evaluation deactivated

Fig. 9-33: Structure of the position encoder type parameter

**Pre-requisites for correctly generating absolute position information:**

The correct generation of the machine zero-point related feedback position value is only possible if the relevant conditions have not changed. The conditions for the correct conversion of the measurement system related position information into the machine zero point related actual position value are made up of:

**Monitoring absolute encoder evaluation conditions**

- the rotational direction of the measuring system set in parameters **S-0-0277, Position feedback 1 type** or **S-0-0115, Position feedback 2 type** in bit 3
- the position polarity set in **S-0-0055, Position polarities**
- the multiplication in parameters **S-0-0256, Multiplication 1** or **S-0-0257, Multiplication 2** calculated using **S-0-0278, Maximum travel range** .
- the value stored in the parameters **S-0-0177, Absolute distance 1** or **S-7-0177, Absolute distance 1.**

If one of these four conditions changes, then the position status of the relevant measuring system is cleared (**S-0-0403, Position feedback value status** = "0“) and the error **F276 Absolute encoder out of allowed window** is generated.

## Absolute Encoder Monitoring

If the absolute evaluation of a measuring system has been activated (position encoder type parameter S-0-0277 or S-0-0115 = 01xx.xxxxb), then in command **S-0-0128, C200 Communication phase 4 transition check** the actual position value is generated and monitored. The monitoring of the actual position value is only active if the encoder is in reference.

**Functional principle of the absolute encoder monitor**

When turning off the drive's power supply, the current actual position of the axis is loaded into resident memory. When switching the axis back on, the difference of the stored position and the newly initialized position of the measuring system is calculated. If this difference is greater than the parametrized position window in parameter **P-0-0097, Absolute encoder monitoring window**, the error message **F276 Absolute encoder out of allowed window** is given.

The absolute encoder monitor is appropriate for the following applications:

- The motor is equipped with a holding brake.
- The drive mechanical system is self-locking and cannot be moved manually.

### Setting the Absolute Encoder Monitor

The absolute encoder monitoring window must be set by the user. Always select a value greater than the maximum allowable motion of the axis when shutdown. Assuming that the axis has a brake or is self-locking, you can enter 0.1 motor revolutions (36° in reference to the motor shaft) as a standard value for the parameter **P-0-0097, Absolute encoder monitoring window**.

### Deactivating the Absolute Encoder Monitor

The absolute encoder monitor cannot be effectively used with axis that can or must be moved manually when switched off. The absolute encoder monitor should be turned off in such situations in order to prevent unnecessary error conditions.

The absolute encoder monitor can be turned off by writing 0 to **P-0-0097, Absolute encoder monitoring window**.

## Modulo Evaluation of Absolute Measuring Systems

If measuring systems are evaluated absolutely and modulo evaluation of the position data is activated, then the following restrictions apply:

The distance which can be traversed when all is shutdown must be smaller than one-half maximum travel range set in parameter **S-0-0278, Maximum travel range.**

## Actual position values of absolute measuring systems after initialization

The condition of the position feedback values of the motor feedback and, if available, of the optional feedback after initializing the position feedback values in the command **S-0-0128, C200 Communication phase 4 transition check** depends on:

- Bit 3 in **S-0-0147, Homing parameter**
- Availability of an absolute feedback as the motor or optional feedback.
- The reference of the relevant absolute encoder.

| Motor feedback: | Optional feedback: | S-0-0147 Bit 3: | S-0-0051, Position feedback value 1: | S-0-0053, Position feedback value 2: | S-0-0403, Pos. status: |
|---|---|---|---|---|---|
| absolute | not absolute | 0 | absolute value of motor feedback | absolute value of motor feedback | 1 |
| absolute | not absolute | 1 | absolute value of motor feedback | absolute value of motor feedback | 0 |
| not absolute | absolute | 0 | absolute value of optional feedback | absolute value of optional feedback | 0 |
| not absolute | absolute | 1 | absolute value of optional feedback | absolute value of optional feedback | 1 |
| absolute | absolute | arbitrary | absolute value of motor feedback | absolute value of optional feedback | 1 |

Fig. 9-34: Position feedback values of absolute measurement systems after initialization

**Note:** When changing polarity, scaling, gearbox and so on it is possible to lose the absolute reference (see also **S-0-0403, Status Actual position values**).

# 9.4 Drive Limitations

## Current Limit

Controllers, motors and machines are subject to various limits to protect them against damage from overload. This protection is based on a **dynamic drop of the current** computed for the output stage of the controller and the motor, in addition to parameters set by the user for another purpose.

The maximum current that may flow for a short period of time or that is available as continuous current is specified in the relevant parameters

- **P-0-4046, Active peak current** and
- **P-0-4045, Active permanent current**.

### Pertinent Parameters

- **S-0-0110, Amplifier peak current**
- **P-0-4004, Magnetizing current**
- **S-0-0109, Motor peak current**
- **S-0-0111, Motor current at standstill**
- **S-0-0092, Bipolar torque/force limit value**
- **P-0-0109, Torque/force peak limit**
- **P-0-4011, Switching frequency**

### Functional Principle

**P-0-4046, Active peak current**

Using parameters **S-0-0092, Bipolar torque/force limit value** and **P-0-0109, Torque/force peak limit** the user limits current and torque to a fixed maximum value.

The maximum possible currents for the machine are fixed by the peak current of the machine and the peak current of the motor. These values may not be exceeded. And, as these are the total flowing currents, the magnetization current is deducted from these values for display in parameter **P-0-4046, Active peak current**.

**Motor current limitation**

The current is dynamically reduced to 2.2-times of the standstill current of the motor to protect the motor against overheating. (Motor current limitation).

**Thermal current limit of the controller**

To protect the controller from overheating, the current is dynamically reduced to **P-0-4045, Active permanent current**. (Thermal current limit of the controller).

**Note:** At high speeds, the maximum possible motor current is also reduced by the pullout current limit.

The smallest value derived from all these limitations is displayed in parameter **P-0-4046, Active peak current**. The controller can supply this maximum current momentarily.

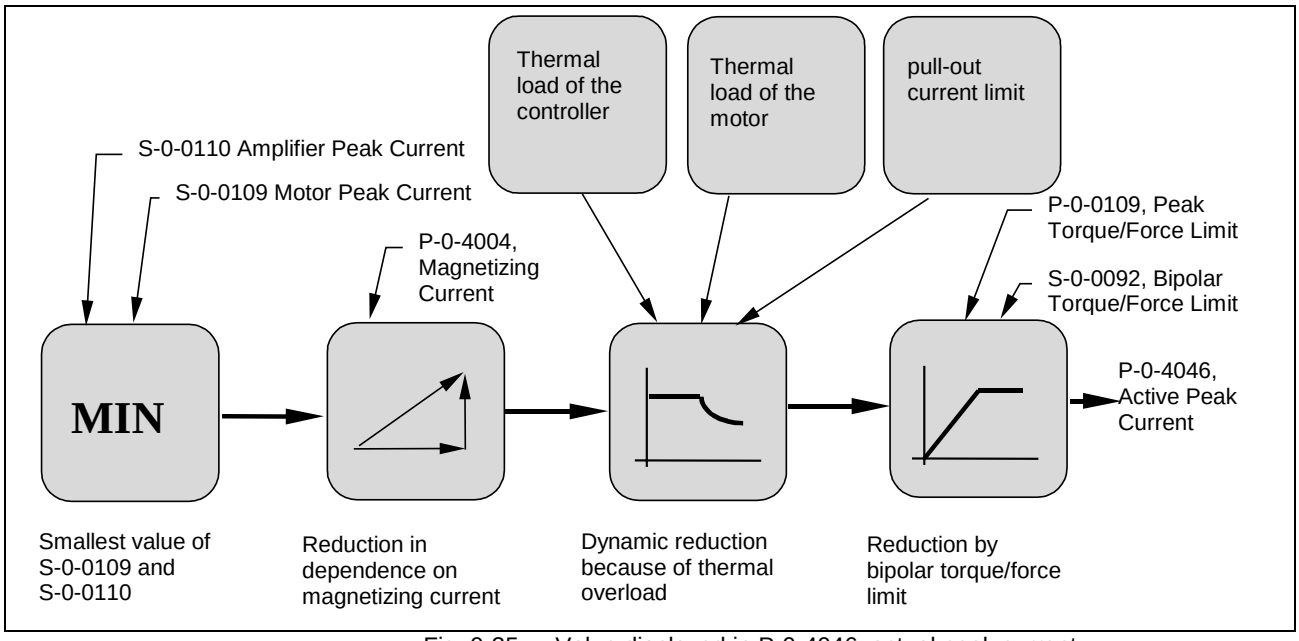

Thermal load of the controller
Thermal load of the motor
pull-out current limit
S-0-0110 Amplifier Peak Current
S-0-0109 Motor Peak Current
P-0-4004, Magnetizing Current
P-0-0109, Peak Torque/Force Limit
S-0-0092, Bipolar Torque/Force Limit
MIN
P-0-4046, Active Peak Current
Smallest value of S-0-0109 and S-0-0110
Reduction in dependence on magnetizing current
Dynamic reduction because of thermal overload
Reduction by bipolar torque/force limit

Fig. 9-35: Value displayed in P-0-4046, actual peak current

**P-0-4045, Active permanent current**

That current displayed in parameter **P-0-4045, Active permanent current** is the continuous current value available from the drive. This current depends largely upon

- the machine type and
- the switching frequency of the output stage.

This **unit-specific** value is additionally reduced by the magnetization current as parameter **P-0-4045, Active permanent current** only displayed the torque-generating portion of the motor current.

**Note:** If the effective peak current is smaller than the effective continuous current, then the effective continuous current is set to the value of the effective peak current. This can be the case if the peak motor current is smaller than the continuous current of the controller or the current limit of the motor reduces the current to under the continuous current of the controller.

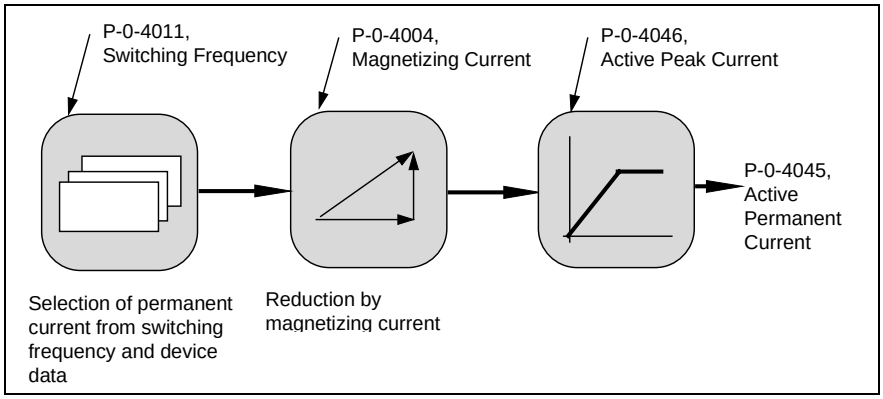

P-0-4011, Switching Frequency
P-0-4004, Magnetizing Current
P-0-4046, Active Peak Current
P-0-4045, Active Permanent Current
Selection of permanent current from switching frequency and device data
Reduction by magnetizing current

Fig. 9-36: Parameter value of the effective continuous current

**Thermal current limit of the controller**

It is the task of the thermal current limit of the controller to **protect the unit against overheating**. To do so, the thermal controller load **(P-0-0141**) is computed from

- the controller-specific data,
- the command current profile and
- the selected switching frequency.

If this reaches 100%, then the peak current is reduced.

The maximum current that can be continuously supplied by the controller, is displayed in parameter **P-0-4045, Active permanent current**. This current also leads to a 100% load. To what extent and how quickly the current can be reduced depends on how the actual current supplied by exceeds the effective continuous current.

Should the current being supplied once again drop to under the effective continuous current, then the load of the unit sinks and the maximum possible current increases.

To monitor the thermal controller load, two warnings are issued:

- **E257 Continuous current limit active** is issued when the load reaches 100%.
- **E261 Continuous current limit pre-warning** is issued when the load reaches the value set in parameter **P-0-0127, Overload warning**.

This means that a response to any eventual overload is possible even before a peak torque reduction. It makes sense to parametrize a value of **80%** for this purpose. This value should not be exceeded when operating the drive under normal conditions.

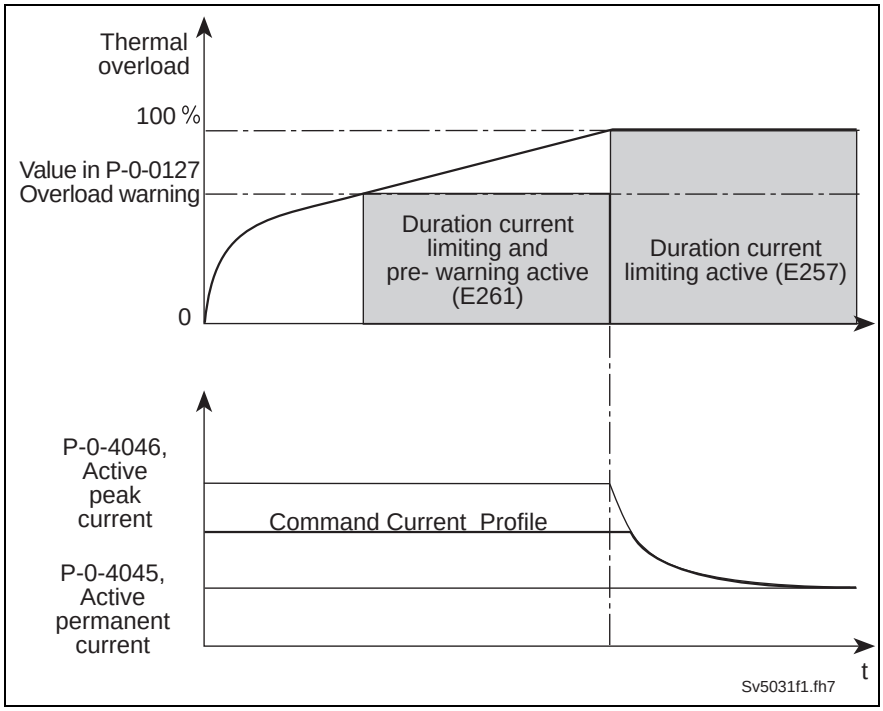



Fig. 9-37: Monitoring the thermal load and continuous current limit

**Checking the thermal load of the drive controller**

Parameter **P-0-0141, Thermal drive load** can be used to check the extent of the controller load. A correct layout would mean that this would never exceed 80%.

To check the load it is possible to subject the machine to a test run. The time until the load achieves a stationary condition must be greater than 10 minutes.

To check the thermal load of a drive at the time of a start-up without having to run a machining process, it is possible to pre-set the controller load to 80%. To do so, write any value into parameter **P-0-0141, Thermal drive load**. It is necessary to briefly and simultaneously run a typical processing cycle, however. The thermal load should be observed and it must demonstrate a falling tendency as otherwise the drive has been incorrectly sized for the application. To check the further increase of the thermal load beyond 80% use

- the overload warning **P-0-0127, Overload warning** and/ or
- the **P-0-0141, Thermal drive load** output

using the analog output.

A typical curve of the thermal load as can be observed with analog output, is displayed below.

**Note:** By pre-setting **P-0-0141, Thermal drive load** to 80%, the processing cycle is set to this load.

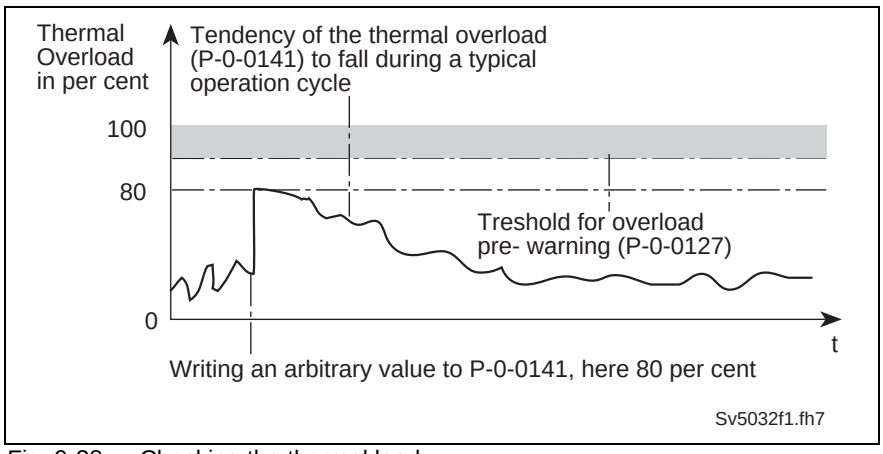



Fig. 9-38: Checking the thermal load

**Motor current limit**

The motor may be loaded for a maximum of 400 msec with the 4-fold value of **S-0-0111, Motor current at standstill**. During continuous operation, a 2.2-fold value is permitted. If the maximum value is exceeded for an extended period, however, then the motor current limit reduces the maximum motor current to 2.2-times the motor standstill current.

For the maximum motor current to increase again, it is necessary to first reduce the load on the motor, i.e., the current must drop below the 2.2-fold motor standstill current.

If the motor overload limit is active then

- warning **E225 Motor overload** is generated and
- Bit 0 (overload warning) in **S-0-0012**, **Class 2 diagnostics** is set.

**Pull-out current limit**

For physical reasons it is necessary to limit the maximum actual current of the motor to a specific speed. The pull-out current limit is used for this purpose. This limit is limited purely by the technical structure of the motor and cannot be influenced. Parameter **P-0-0532, Premagnetization factor** is used to set this in asynchronous motors. (See section: "Asynchronous Motors".)

# Torque Limit

Parameters

- **S-0-0092, Bipolar torque/force limit value**
- **P-0-0109, Torque/force peak limit**

specify the per cent value of **S-0-0111, Motor current at standstill * Factor cooling type** that can be maximally made available. The factor of the cooling type is derived from that cooling type of the motor which has been programmed in parameter P-0-0640:

| Cooling mode | Parameter value<br>P-0-0640Cooling type | Factor |
|---|---|---|
| uncooled | 0 | 100 % |
| cooled | 1 | 150 % |
| water cooled | 2 | 190 % |

Fig. 9-39: Factor cooling type

**Variable torque limit**

Parameter **S-0-0092, Bipolar torque/force limit value** is used to specify variable limits of the maximum drive torque to values smaller than the maximum possible one. This makes sense, for example, given a successive and quick approaches to an end limit.

**Peak torque limit**

Due to the maximum allowable current of any motor/controller combination, there is a specific peak torque which is desirable with many applications for acceleration processes. There are, however, cases where the maximum peak torques must be limited to lower values for application reasons. Parameter **P-0-0109, Torque/force peak limit** can be used to limit the maximum peak torque of a drive for an application. This parameter ensures that the allowable maximum peak torque for an application then not exceeded even if **S-0-0092, Bipolar torque/force limit value** is set to a high value.

The following illustrates the interplay of current limit and torque limit for determining the maximum output current.

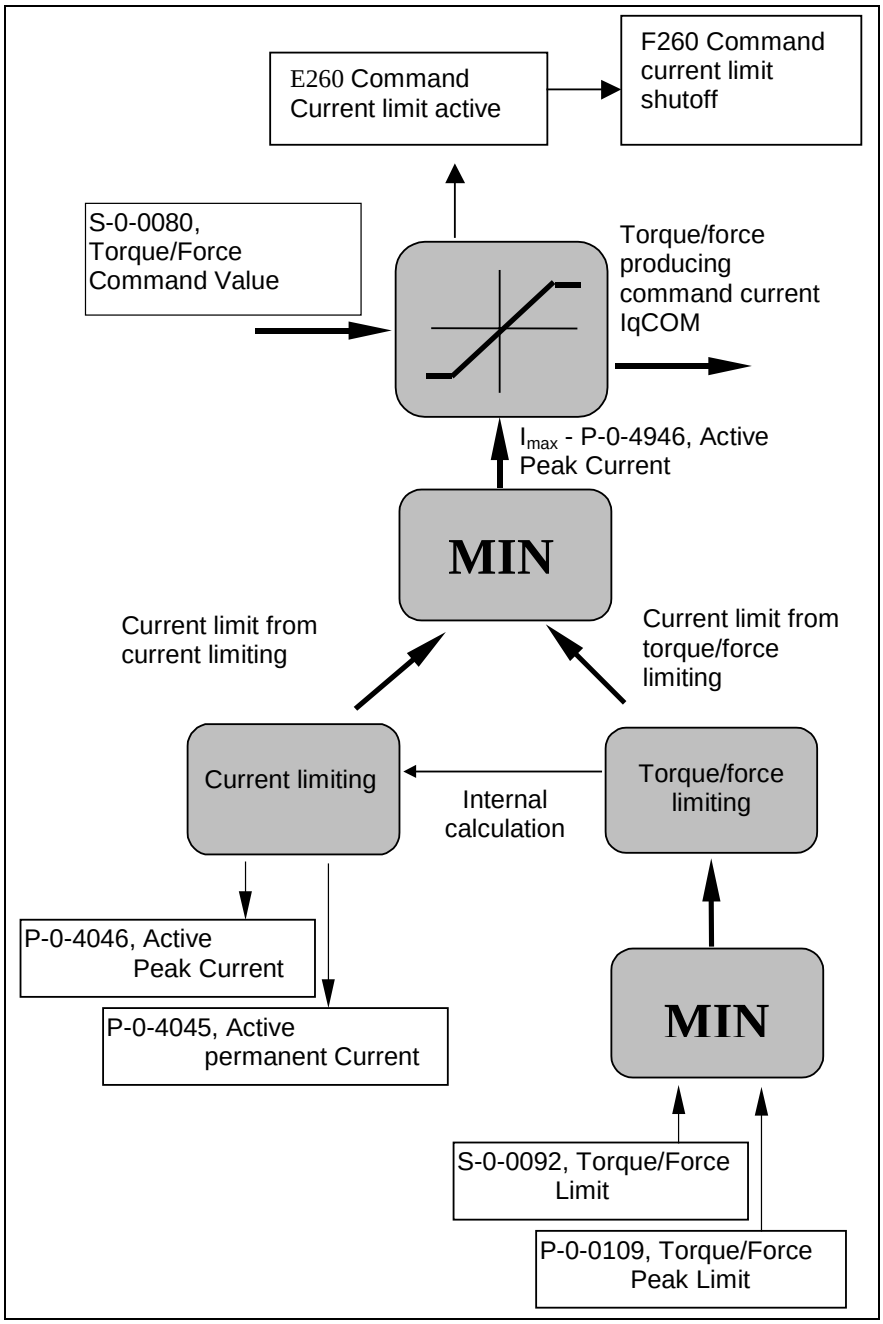



Fig. 9-40: Current limitation and torque/force limitation

The current and torque limits both effect the limit of the torque-generating command current displayed in parameter **P-0-4046, Active peak current**.

**Note:** The smaller of the two limit values is effective in this case!

**Warning and Errors:**

If the peak current limitation is active, then the drive generates warning **E260 Command Current limit active**. If the drive remains here for more than 5s, then it shuts itself down with error message **F260 Command current limit shutoff**.

This function can be switched on via **P-0-0538, Motor function parameter 1** bit 11 = 1. (Load base parameters shuts the function off.) With main spindle axes, the drives are generally accelerated to the current limit which is the reason why this function does not make sense.

**Accel dependent current command value limitation**

The function of accel dependent torque limitation is switched on with bit 12 of parameter **P-0-0538, Motor function parameter 1**.

The required accel torque is computed based on load moment of inertia, torque constant and specified command value accel. Parameter **S-0-0092, Bipolar torque/force limit value** can then be set to the required machining torque. Parameter **P-0-0109, Torque/force peak limit** always limits the maximum available torque and is set to the maximum value appropriate to the machine.

Generating the accel command value with position-controlled drives:

$$a_{soll} = dv_{soll}/dt = d^2x_{soll}/dt^2$$

$x_{soll}$: Command position at position controller
$v_{soll}$: Command velocity on speed controller
$a_{soll}$: Command accel

Fig. 9-41: Accel command values with position-controlled drives

Generaing the accel command value with speed-controlled drives:

$$a_{soll} = dv_{soll}/dt$$

Fig. 9-42: Accel command value with speed-controlled drives

Required torque equals:

$$M_B = a_{soll} * J_{ges} = a_{soll} *(J_{Mot} + J_{Last})$$

$J_{Mot}$: Motor moment of inertia
$J_{Last}$: Load inertia

Fig. 9-43: Required torque

Required torque-generating motor current:

$$i_B = (a_{soll} * J_{ges})/Km$$

Km: Torque constant of motor
$i_B$: Accel current

Fig. 9-44: Motor current

The allowed maximum current thus equals

$$I_{max} = S\text{-}0\text{-}0092 * I_{DauerMotor}/100\% + | I_B |$$

$I_{DauerMotor}$: S-0-0111, Motor current at standstill

Fig. 9-45: Maximum current

or if the value is smaller than:

$$I_{max} = P\text{-}0\text{-}0109 * I_{DauerMotor}/100\%$$

Fig. 9-46: Maximum current

### Determining the torque constant and load moment of inertia

The torque constant in Rexroth Indramat synchronous motors is in the motor data memory. The tolerance (especially via temperature) equals about - 5%...+20%.

The load moment of inertia can be set with the automatic control setting. The tolerance error of the torque constant is automatically allowed for when determining the load moment of inertia by means of the automatic controller setting!

---

**Note:** Error reactions leading to velocity to zero (**P-0-0119, Best possible deceleration** =0) and fatal warnings, mean that the torque is limited to the value set in **P-0-0109, Torque/force peak limit**.

---

## Limiting Velocity

The following parameters limit the velocity of the drive:

- **S-0-0113, Maximum Motor Speed (nmax)**
- **S-0-0091, Bipolar Velocity Limit Value**

The parameter **S-0-0091, Bipolar Velocity Limit Value** is designed to allow variable limits of the maximum velocity to values smaller than the maximum allowable velocity during operation.

The parameter **S-0-0113, Maximum Motor Speed (nmax)**designates the maximum possible motor velocity. It is contained in the motor encoder data storage of MHD-, MKD and MKE motors and does not need to be entered, but with other types of motors this value must be taken from the motor parameter specifications.

### Limiting to Maximum Motor Velocity

The maximum motor velocity defines the maximum velocity of the drive. It becomes active and is included in the calculation of

- the maximum value entered in the parameter **S-0-0091, Bipolar Velocity Limit Value**

### Limiting to Bipolar Velocity Limit Value

The bipolar velocity limit value defines the maximum velocity of the drive for the user. It becomes active as

- the monitor of the encoder velocity in the **torque control** operating mode
- the limit for the resulting command value in the velocity controller
- the monitor of the position command value difference in the **position control** operating mode

  (see also "Position Command Value Monitoring")
- the limit of **S-0-0036, Velocity Command Value** in the **velocity control** operating mode

**Monitoring the Feedback Velocity in the Torque Control Operating Mode**

Monitoring the Feedback Velocity in the **Torque Control** operating mode occurs at 1.125 times the value of **S-0-0091, Bipolar Velocity Limit Value**. If this value is exceeded, the fatal error

- **F879 Velocity limit S-0-0091 exceeded**

is generated. The drive switches to torque-free operation afterwards.

**Limiting the Resulting Command Value in the Velocity Controller**

In all operating modes in which the velocity controller is active (all operating modes except for **Torque Control**), the given velocity command value is limited to the value of **S-0-0091, Bipolar Velocity Limit Value**. If this condition is reached, the warning

- **E259 Command Velocity Limit active**

is generated.

**Limiting S-0-0036, Velocity Command Value in the Velocity Control Operating Mode**

In the velocity control operating mode, the input of **S-0-0036, Velocity Command Value** is limited to **S-0-0091, Bipolar Velocity Limit Value**. If the value entered in S-0-0036 exceeds this limit, the warning

- **E263 Velocity command value > limit S-0-0091**

is generated.

# Travel Range Limits

To avoid accidents and damages to the machine, many safety precautions are provided. A part of these safety measures refers to limiting the allowed working range.

These limits can be introduced by the following measures:

- Software limits in the control (only active with axis in reference)
- Position limits in the drive (only active with axis in reference)
- Limit switches in the drive
- Safety limit switches (in the emergency/safety chain)

## Relevant Parameters

- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**
- **S-0-0055, Position polarities**
- **S-0-0403, Position feedback value status**
- **P-0-0090, Travel limit parameter**
- **P-0-0222, Status Inputs travel range limits**

## Functional principle of travel range limits

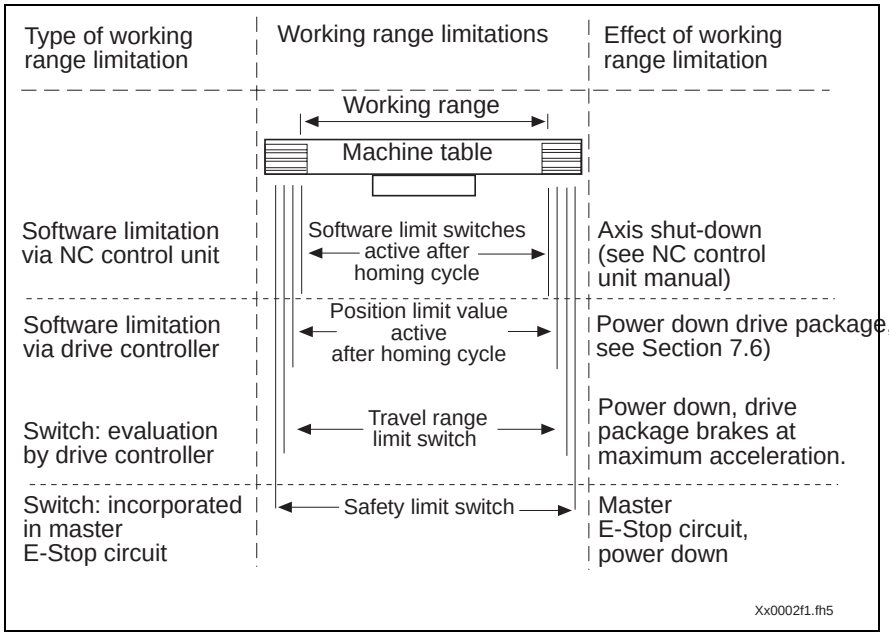

Type of working range limitation
Working range limitations
Effect of working range limitation
Working range
Machine table
Software limitation via NC control unit
Software limit switches active after homing cycle
Axis shut-down (see NC control unit manual)
Software limitation via drive controller
Position limit value active after homing cycle
Power down drive package, see Section 7.6)
Switch: evaluation by drive controller
Travel range limit switch
Power down, drive package brakes at maximum acceleration.
Switch: incorporated in master E-Stop circuit
Safety limit switch
Master E-Stop circuit, power down
Xx0002f1.fh5

Fig. 9-47: Effect and ways of limiting the working range

There are two methods in the drive itself.

These are the monitors for

- Travel zone limit switches and
- Position Limit Values for the axis

The travel range is exceeded when either a travel zone limit switch is activated or one of the two axis limit values is exceeded by the homed position feedback value, the value which refers to the machine zero point.

The drive's response to exceeding the travel range is selectable. The following possibilities exist:

- An error with a "Set Velocity Command Value to Zero" reaction and automatic drive enable shutoff
- A warning with a "Set Velocity Command Value to Zero" reaction and automatic reset when the error conditions are gone.

This is set in bit 2 of **P-0-0090, Travel limit parameter**:

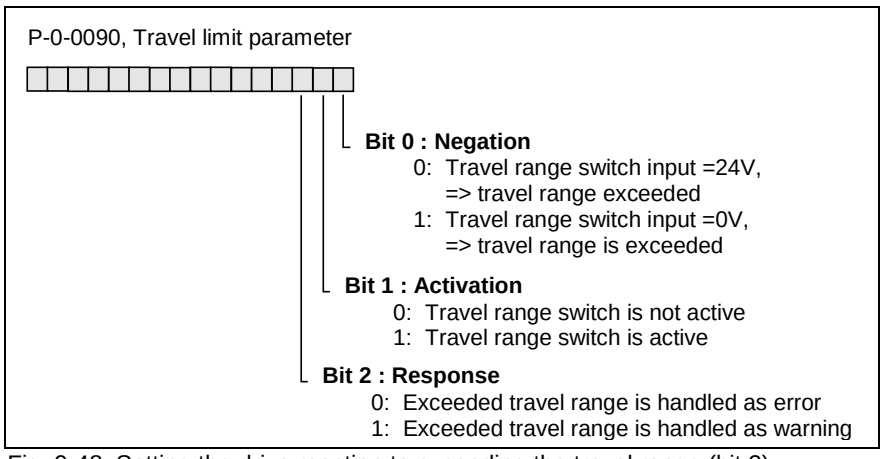

P-0-0090, Travel limit parameter
Bit 0 : Negation
0: Travel range switch input =24V, => travel range exceeded
1: Travel range switch input =0V, => travel range is exceeded
Bit 1 : Activation
0: Travel range switch is not active
1: Travel range switch is active
Bit 2 : Response
0: Exceeded travel range is handled as error
1: Exceeded travel range is handled as warning

Fig. 9-48: Setting the drive reaction to exceeding the travel range (bit 2)

**Note:** Decelerating the axis with the use of a velocity command value ramp is not possible! Braking always occurs at maximum allowable torque

(see **P-0-4046, Active peak current**).

## Exceeding the Travel Range as an Error

If a 0 is entered in bit 2 of P-0-0090, then exceeding the travel range is handled as an error with the reaction of the velocity command value being set to zero. (See also chapter: "Velocity Command Value Reset".)

After the velocity command value has been set to zero, the drive turns off the internal drive enable and becomes torque-free. The ready-to-operate contact opens.

For re-installation

- Clear the error with the command **S-0-0099, C500 Reset class 1 diagnostic** or press the S1 button.
- Reactivate the drive with the 0-1 edge of the drive enable signal.

If the error condition is still present, that is, if the limit switch is still activated or if the axis limits are still exceeded, only command values that go back into the allowable range will be accepted. Monitoring the command values is dependent on the active operating mode.

The following applies:

| **Operating Mode:** | **Command Value Check:** |
|---|---|
| Torque control | Polarity of **S-0-0080, Torque/Force command** |
| All operating modes with drive-internal velocity control | Polarity of the internal velocity command value |
| All operating modes with drive-internal position control | Polarity of the velocity created by the given position command values |

Fig. 9-49: Monitoring the command values in error conditions

If command values are given that would lead out of the allowable travel range, the travel range error will be generated again.

## Exceeding the Travel Range as a Warning

If a 1 is entered in bit 2 of **P-0-0090, Travel limit parameter,** then exceeding the travel range as a warning is handled with setting the velocity command value to zero.

The drive does not turn off its internal drive enable. If the error condition is still present, that is, if the limit switch is still activated or if the axis limits are still exceeded, only command values that go back into the allowable range will be accepted. Monitoring the command values is dependent on the active operating mode. (See previous section.)

**Note:** When there is an error with the reaction of the position limit switches, for example, if both limit switches are activated at the same time, then this will be handled as an error , like in the situation when "exceeding the limit switch is handled as an error" is parameterized. The drive will generate both error diagnostic messages, **F643 Positive travel limit switch detected** and **F644 Negative travel limit switch detected**.

## Travel Zone Limit Switch Monitoring

The state of the travel range limit switch is illustrated in parameter **P-0-0222, Status Inputs travel range limits**. Bit 0, in this case, is the positive end switch, bit 1 the negative one.

The monitor for exceeding the travel zone limit switch is only activated if

- the monitor is switched on in bit 1 of **P-0-0090, Travel limit parameter**

Exceeding the travel zone limit switch is recognized when these are activated. The diagnostic message depends on the type of reaction:

| How handled: | SS display: | Diagnostic message: |
|---|---|---|
| As an error | F643 | **F643 Positive travel limit switch detected** |
| | F644 | **F644 Negative travel limit switch detected** |
| As a warning | E843 | **E843 Positive limit switch activated** |
| | E844 | **E844 Negative limit switch activated** |

Fig. 9-50: Diagnostic message when travel zone limit switch is exceeded

## Travel Zone Limit Switches - Activation and Polarity

The travel zone limit switches are activated with the parameter **P-0-0090, Travel limit parameter**. Additionally, the inputs can be inverted in this parameter ( 0V on E2/3 -> Travel range exceeded ).

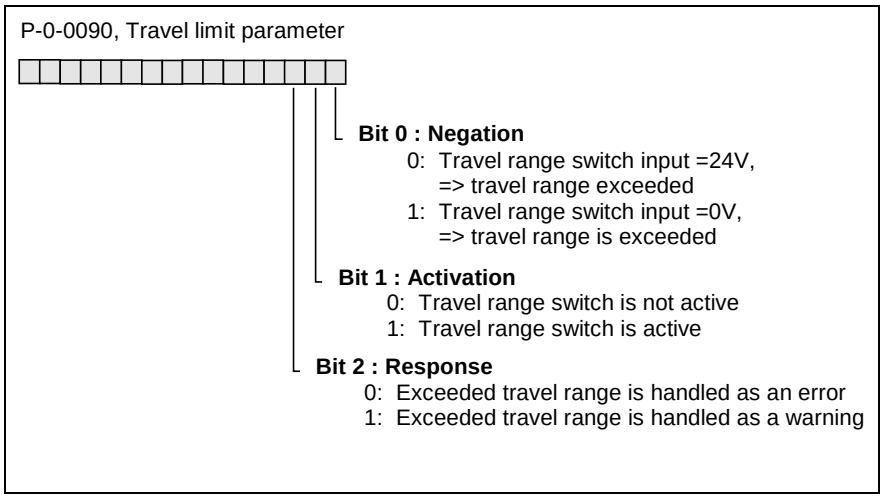

P-0-0090, Travel limit parameter
Bit 0 : Negation
0: Travel range switch input =24V,
=> travel range exceeded
1: Travel range switch input =0V,
=> travel range is exceeded
Bit 1 : Activation
0: Travel range switch is not active
1: Travel range switch is active
Bit 2 : Response
0: Exceeded travel range is handled as an error
1: Exceeded travel range is handled as a warning

Fig. 9-51: Activating and negating the limit switches (bit 0 or 1)

## Axis Limit Values

The monitor for exceeding the axis limit parameters:

- **S-0-0049, Positive position limit value**
- **S-0-0050, Negative position limit value**

is executed only if

- one of the encoder systems is homed, that is, when at least one actual position value refers to the machine's zero point.

AND

- the monitoring of the position limit values in **S-0-0055, Position Polarity parameter**, Bit 4 has been activated.

The monitoring is done, as a default, with the position value of the encoder defined with **S-0-0147, Homing parameter** (bit 3). If this encoder is not homed, the monitoring is performed with the second encoder, as long as it is present and homed.

Exceeding the position limits is recognized, when the monitored position value exceeds the travel range defined by the position limits.

If drive-internal interpolation is used as the active operating mode, the drive checks to see if the target position is outside of the axis limit values. If it is, the drive will not move and the warning **E253 Target position out of travel range** is generated, and bit 13 in parameter **S-0-0012, Class 2 diagnostics** is also set.

The diagnostic message in the case that the axis limit values have been exceeded depends on the type of reaction:

| How handled: | SS display: | Diagnostic message: |
|---|---|---|
| As an error | F629 | **F629 Positive travel limit exceeded** |
| | F630 | **F630 Negative travel limit exceeded** |
| As a warning | E829 | **E829 Positive position limit exceeded** |
| | E830 | **E830 Negative position limit exceeded** |

Fig. 9-52: Diagnostic message when axis limits have been exceeded

## Axis Limit Values - Activation

The axis limit value monitor is activated in bit 4 of **S-0-0055, Position polarities**.

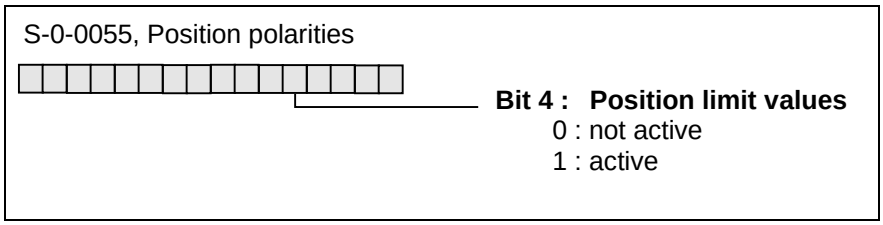



Fig. 9-53: Activating the axis limits

## Travel Zone Limit Switches - Connection

see project planning manual

# 9.5 Master Axis Feedback Analysis

## The Functional Principle of Master Axis Feedback Analysis

This function analyzes a master axis feedback in the drive control . The master axis encoder can be evaluated parallel to the motor encoder as an optional measuring system and supports detection of the position of a mechanical shaft from which either the control velocity or position command values are computed in the drive. The "Master Axis Feedback Analysis" is activated with **P-0-0185, Function of encoder 2** = 1 or 5.

The drive can be operated in the following modes:

- **velocity synchronisation with real master axis,**
- **phase synchronisation with real master axis**, or
- **electronic cam shaft with real master axis**

In the drive, the position of the master axis is directly derived from the position of the master axis encoder and then, in turn, the velocity and position command values.

As an alternative, there is the option of transmitting of the actual position value of the master axis encoder (**P-0-0052, Position feedback value 3**) cyclically to the control which then generates the master axis position (**P-0-0053)** from this information. This is then cyclically transmitted to one or several drives.

The drive can also be operated in the following modes:

- **velocity synchronisation with virtual master axis,**
- **phase synchronisation with virtual master axis**, or
- **electronic cam shaft with virtual master axis**

The drive calculates velocity or position command values using the master axis position received from the control.

The position feedback value of the lead drive feedback is available in **P-0-0052, Position feedback value 3**.

## Parameterizing the Master Axis Feedback

For the master axis encoder it is possible to use either a cyclical absolute measuring system or an incremental encoder with sine or square-wave signals.

**Note:** The measuring systems must all have a binary encoder resolution!

In an ECODRIVE03 the feedback connection not needed by the motor encoder interface can be used to evaluate the master axis encoder.

| Measurement System: | Function | P-0-0074/ P-0-0075 | Interface | Note |
|---|---|---|---|---|
| HSF | absolute cyclical | 1 | X4 | in MKD and MHD motors the X4 interface is assigned to the motor encoder and cannot, therefore, be used for the master axis encoder |
| Endat | absolutel cyclical | 8 | X8 | expensive, typically 2048 number of lines |
| incremental with sine signals (1Vss signals | incremental | 2 | X8 | maximum input frequency : 200kHz ! |
| incremental with TTL signals | incremental | 5 | X8 | maximum input frequency: 200kHz ! |

Fig. 9-54: Measuring systems and parametrization with master axis encoders

To parametrize the master axis encoder use parameters

- **P-0-0075, Feedback type 2**
- **S-0-0115, Position feedback 2 type**
- **S-0-0117, Feedback 2 Resolution**
- **P-0-0185, Function of encoder 2**
- **P-0-0186, Actual Position value 3, smoothing time**.

The parameter **P-0-0052, Position feedback value 3** displays the position of the master axis feedback.

To use the optional encoder as a master axis encoder, a 1 must be entered in parameter **P-0-0185, Function of encoder 2**.

The position feedback value-3 can be given an offset. Use the parameter **P-0-0087, Offset position feedback value 3** to do this.

The format of the position feedback value 3 is $2^{20}$ increments per revolution, and the format cannot be changed.

## Determining the Feedback Interface of the Master Axis Feedback

Determining the encoder interface of the master axis encoder uses parameter **P-0-0075, Feedback type 2**. Enter the number of the encoder there. If an "0" is entered, then encoder evaluation is switched off.

## Master Axis Feedback Resolution

The resolution must be entered in parameter **S-0-0117, Feedback 2 Resolution**.

Parametrization of the resolution of the master axis encoder is only needed if an encoder with feedback data storage capabilities is not used.

## Rotational Direction of the Master Axis Encoder

To parametrize the rotational direction of the master axis encoder use bit 3 of **S-0-0115, Position feedback 2 type.**

## Smoothing the actual position value

The non-linearized position value can be smoothed using a low-pass filter. The time constant is fixed with parameter **P-0-0186, Actual Position value 3, smoothing time**.

**Note:** Position errors caused by the accuracy of the encoder can be suppressed with this filter. Any oscillations of the master axis encoder can also be attenuated. If the actual position value 3 is transmitted to other drives as a master axis position then this will help achieve a considerably quieter run of the slave axes.

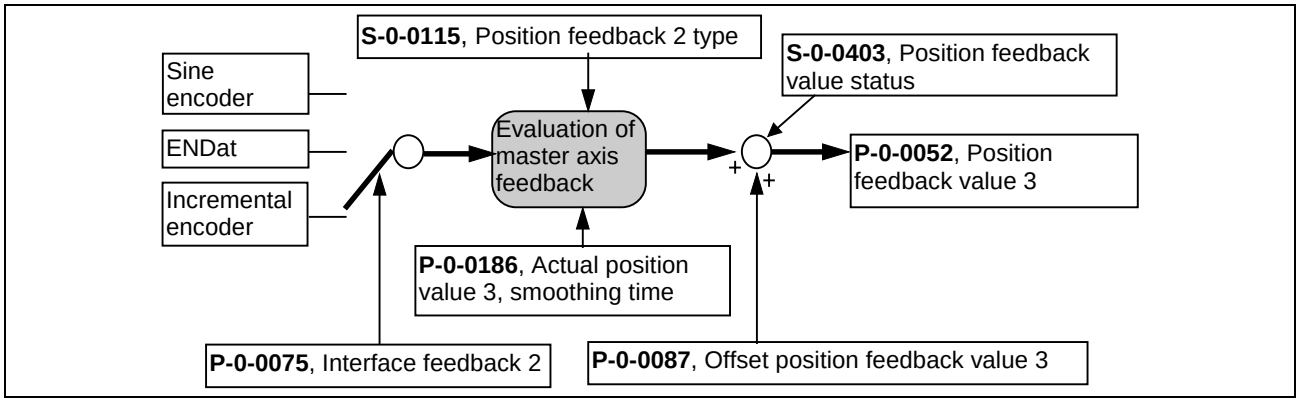



Fig. 9-55: The principle of master axis encoder evaluation

## Referencing the master axis encoder

Cyclically absolute measuring systems supply, after being powered up, absolute positions within one revolution and therefore do not have to be referenced. A single setting of parameter **P-0-0087, Offset position feedback value 3** can set the desired position.

Incremental measuring systems cannot supply an absolute position until their zero pulse has been situated.

- In addition to the position status of the motor encoder (bit 1) parameter **S-0-0403, Position feedback value status** also contains the position status of the optional encoder (bit 2). This means that in bit 2 the position status of the master axis encoder is available.
- If an incremental measuring system is used as a master axis encoder, then its position status is "0" once it is turned on. The detection of the zero pulse is active if the position status of the master axis encoder = 0. To detect the zero pulse it is necessary to "overrun" it.
- After detecting the zero pulse, the master axis position jumps to its absolute value. The position of the zero pulse equals parameter **P-0-0087, Offset position feedback value 3.**
- If the procedure of detecting the zero pulse is to be repeated then by using command **S-0-0191, D600 Cancel reference point procedure command** it is possible to clear the position status of the master axis encoder. The procedure to detect the zero pulse is again conducted.

**Note:** If there is a real master axis encoder, then independent of bit 3 in **S-0-0147, Homing parameter**, only the position status of the master axis encoder is cleared.

With **P-0-0185, Function of encoder 2** = 1, encoder 2 is evaluated as master axis encoder. Incremental encoders that overrun the zero pulse are automatically referenced. With P-0-0185 = 5 master axis encoder referencing is automatically switched off.

# 9.6 Drive Error Reaction

*The error response depends on the current error class.*

If an error is recognized in the drive controller, a preset error response occurs.

This drive error response depends on

- the error class of the current error
- and the setting of the parameters
  - **P-0-0117, NC reaction on error**
  - **P-0-0118, Power off on error**
  - **P-0-0119, Best possible deceleration**

**Note:** The error class defines the behaviour in the event of a fault.

There are 4 error classes, which have different priorities.
(see also "Error Classes")

| Error Class | Diagnostic Messages | Drive Response |
|---|---|---|
| Fatal | F8xx | The error response parameter settings in **P-0-0117, NC reaction on error** and **P-0-0119, Best possible deceleration** will be ignored, since a driver response is impossible. Torque/force is instantly cut off. |
| Travel range | F6xx | Independently of the settings in parameters **P-0-0117, NC Reaction on Error** and **P-0-0119, Best possible deceleration**, the velocity command value is immediately set to zero. This response corresponds to the settings<br>P-0-0117 = 0 (no NC Reaction)<br>P-0-0119 = 0 (Velocity Command Value Reset). This setting provides the fastest stop of the axis if the drive range is exceeded. |
| Interface | F4xx | A response from the control is impossible, since the communication to the control became inoperative. The drive proceeds instantly with **P-0-0119, Best possible Deceleration**. |
| Non-fatal | F2xx<br>F3xx | The drive conducts the decel procedure set in **P-0-0117, NC reaction on error** and **P-0-0119, Best possible deceleration.** If NC reaction is set as an error response, then the drive continues to operate for 30 seconds after detecting an error, as if no error had been detected. The NC has this time to bring the axis to a controlled standstill. The drive then conducts the response set in P-0-0119. |

Fig. 9-56: Error Response of the Drive

## Best Possible Deceleration

The drive reaction **P-0-0119, Best possible deceleration** is conducted automatically with

- interface errors F4xx
- non-fatal errors F2xx

At the end of each error response, the drive's torque is cut off with

- fatal errors F8xx
- travel range errors F6xx

**P-0-0119, Best possible deceleration** is ignored.

The following settings are possible:

| Value of P-0-0119: | Response |
|---|---|
| 0 | Velocity Command Value Reset |
| 1 | Torque Disable |
| 2 | Velocity command value to zero with command ramp and filter |
| 3 | Return motion |

Fig. 9-57: Setting options for Best possible Deceleration

The drive response, which is defined as "Best Possible Deceleration", controls the response of the drive if

- the drive enable signal changes from 1 to 0 (disable the drive enable)
- the operating mode is switched to parameter mode while the drive is enabled. (Reset of the communication phase)

## Velocity Command Value Reset

**Best possible deceleration P-0-0119 = 0**

Given an error, the drive will stop with command value = 0. The drive stops with its maximum permissible torque.

(See also section: "Current Limit").

**Failure reaction sequence with spindle brake present**

The procedure for the motor brake activation (if mounted) and the power stage disable with velocity command value deceleration to zero (with spindle brake) are displayed below.

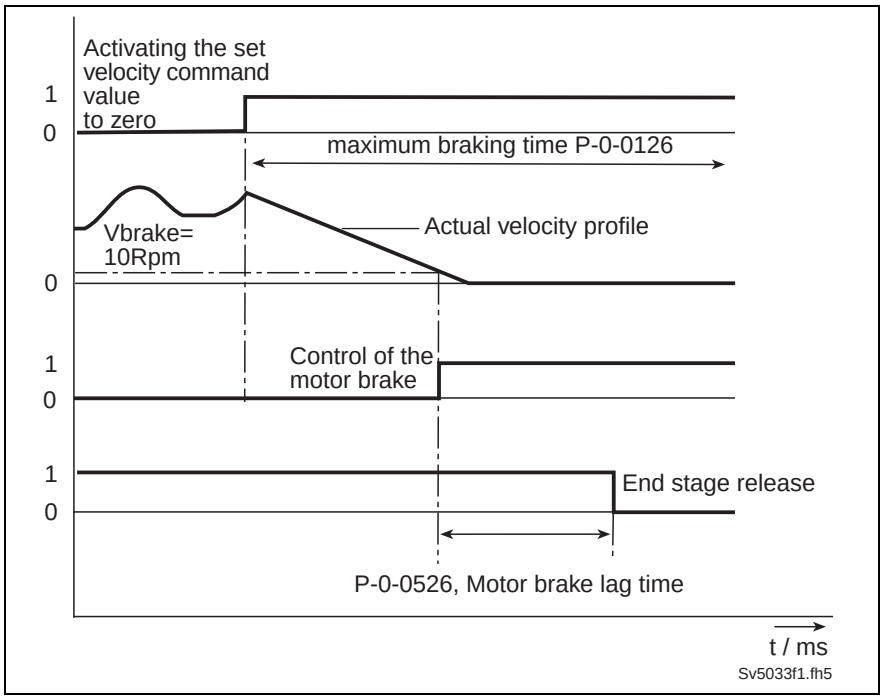



Fig. 9-58: Time sequence of the velocity command value reset

**Note:** Activation of the motor holding brake depends on **P-0-0525,** bit 1.
See section: "Motor Holding Brake"

**Note:** If the value entered in P-0-0126 is too small, then the error reaction could be terminated without axis standstill.

**WARNING**

**Danger of damaging the motor brake if P-0-0126, Maximum braking time is set too low**

⇒ The value for **P-0-0126, Maximum braking time** must always be set higher than the time needed to decelerate the axis with the velocity command value reset, taking maximum possible velocity into account.

## Disable Torque

**Best possible standstill P-0-0119 = 1 or fatal error**

In the event of an error, the drive goes torque free and is braked only by the frictional force, i.e., it "coasts". The actual time to standstill can be considerable especially with spindles.

**Note:** The error reaction "**Torque disable**" is absolutely necessary with **fatal errors (F8xx)** because braking with a defective end stage or feedback is no longer possible!

**DANGER**

**Drive continues to move unbraked with error!**

Danger to life from parts in motion if the machine safety doors are open.

⇒ Check drive for motion (e.g., using **S-0-0040**, **Velocity feedback value,** if possible) and await standstill!

**Note:** Activation of the motor holding brake depends on **P-0-0525**, bit 1.

See section: "Motor Holding Brake"".

The temporal behavior of the brake in conjunction with an error reaction depends on the brake. Please note the advisory under "

Torque disable with brake type: Servo brake".

## Torque disable with brake type: Spindle brake

The motor holding brake is not activated until the motor speed drops **below 10min$^{-1}$.**

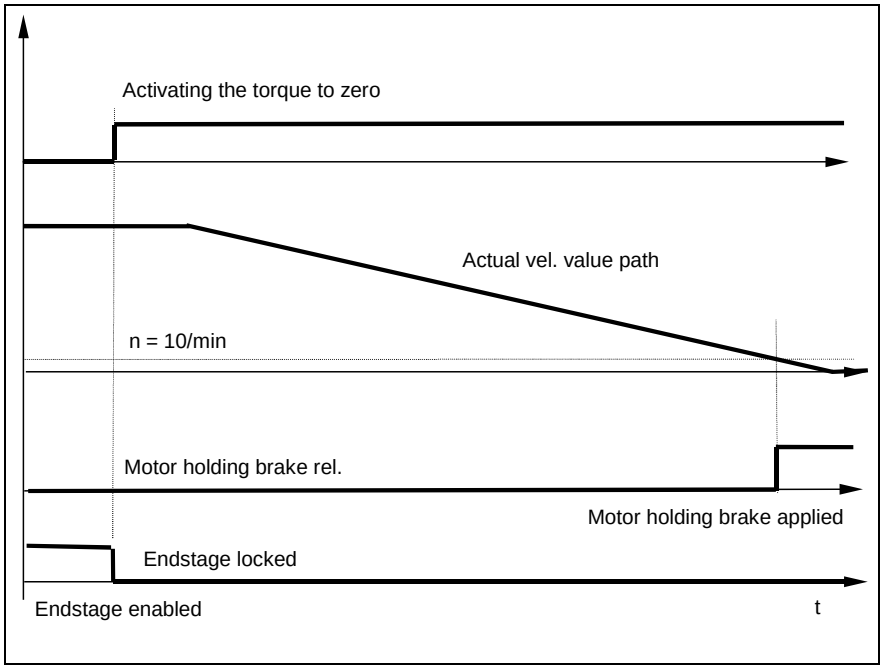



Fig. 9-59: Time diagram with torque to zero and **P-0-0525, Type of motor brake, Bit 1 = 1**

## Torque disable with brake type: Servo brake

The motor holding brake is immediately activated!

**Note:** It is not sensible to set the best possible standstill to torque disable when using a motor holding brake of the servo-brake type at the same time. In this case, when performing the best possible standstill, the drive does not brake actively, but only with the holding brake. After 20000 turns, the brake is at the end of its life.

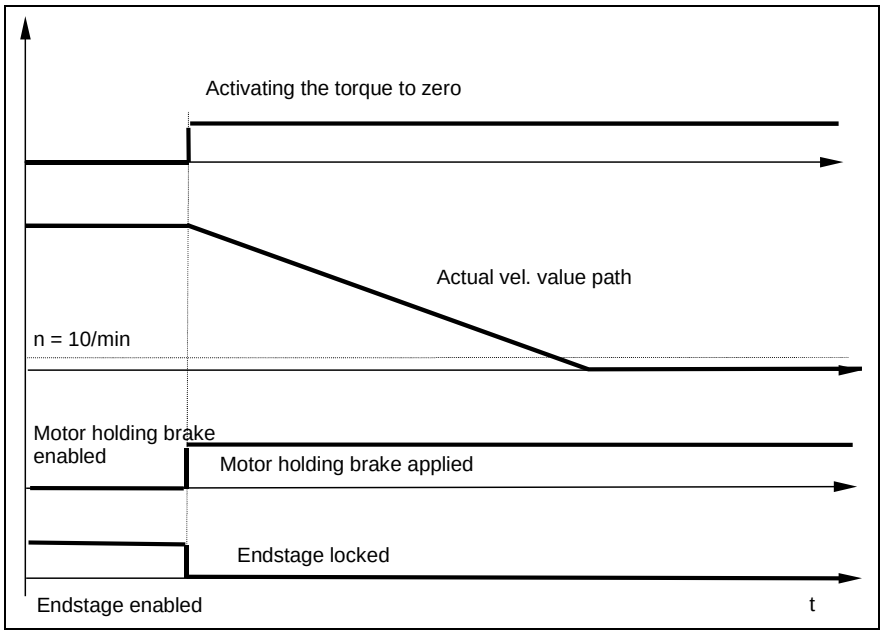



Fig. 9-60: Time diagram with torque to zero and **P-0-0525, Type of motor brake, Bit 1 = 0**

See also chapter: "Motor Holding Brake".

## Velocity command value to zero with filter and ramp

**Best possible standstill**
**P-0-0119 = 2**

In the event of an error the drive is brought to a standstill with velocity control with a command value ramp with end value zero. The velocity command value passes through a jerk-limiting command value smoothing filter.

The parameters used in this case are:

- **P-0-1201, Ramp 1 pitch**
- **P-0-1202, Final speed of ramp 1**
- **P-0-1203, Ramp 2 pitch**
- **P-0-1211, Deceleration ramp 1**
- **P-0-1213, Deceleration ramp 2**
- **P-0-1222, Velocity command filter**

These parameters work as described in section: "Operating Mode: Velocity control".

If parameters **P-0-1211, Deceleration ramp 1** or **P-0-1213, Deceleration ramp 1** are equal to zero, then parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** are used.

If parameters **P-0-1201, Ramp 1 pitch** or **P-0-1203, Ramp 2 pitch** are equal to zero, then the drive brakes without a ramp.

---

**Note:** Activation of the motor holding brake depends on **P-0-0525**, bit 1.

---

See section entitled: "Motor Holding Brake"".

## Return motion

**Best possible Deceleration P-0-0119 =3**

If a 3 has been set for "Best possible Deceleration" as a return motion, then the drive generates a position command profile to complete the desired travel distance in the case of an error. In other words, in the case of an error a relative process (travel) block is activated.

**Note:** If **P-0-0096** is positive, then in reference to the machine coordinate system the drive moves in the positive direction.

This travel block is defined by the parameters

- **P-0-0096, Distance to move in error situation**
- **S-0-0091, Bipolar velocity limit value**
- **S-0-0138, Acceleration bipolar**
- **S-0-0349, Jerk limit bipolar**

Once the drive has covered the distance, i.e., has reached the desired target position, then the motor holding brake is activated (if mounted) and the drive is switched torque free at the end of the motor brake delay time. The distance to move is considered as completed, i.e., the motor holding brake is activated, if

- target position = active position command value, i.e., bit 12 in **S-0-0013, class 3 diagnostics** = 1 and
- $V_{actual}$ = 0, i.e., bit 1 in **S-0-0013, class 3 diagnostics** = 1 (feedback velocity smaller than **S-0-0124, Standstill window**).

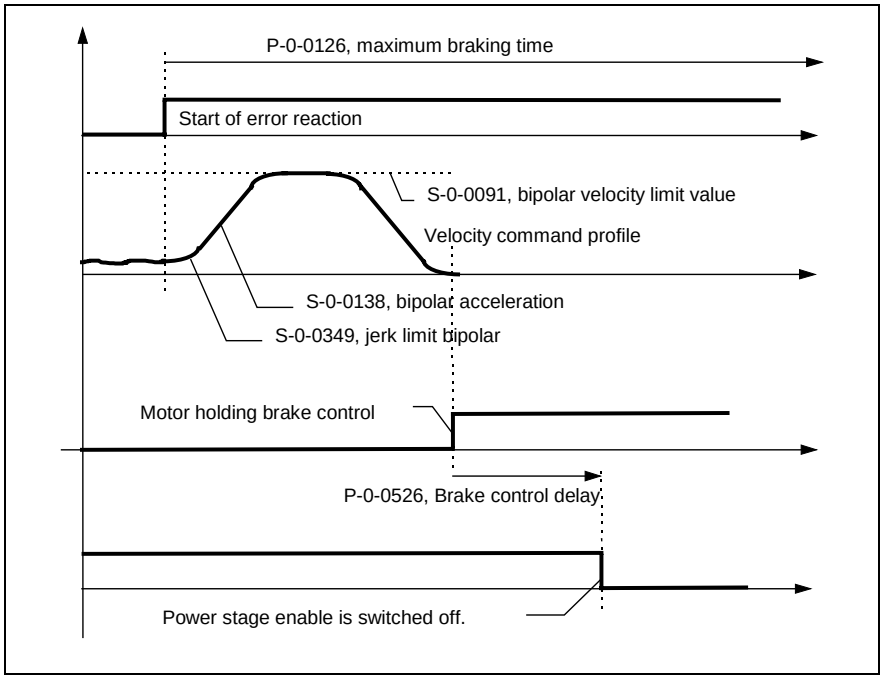

P-0-0126, maximum braking time
Start of error reaction
S-0-0091, bipolar velocity limit value
Velocity command profile
S-0-0138, bipolar acceleration
S-0-0349, jerk limit bipolar
Motor holding brake control
P-0-0526, Brake control delay
Power stage enable is switched off.

Fig. 9-61: Time sequence of the error reaction "return motion“

**Error reaction "Return motion" with position limit values activated**

If the drive-internal position limit values (**S-0-0049, positive position limit value and S-0-0050, negative position limit value**) have been activated, in other words,

- in **S-0-0055, position polarity parameter** bit 4 for "activating the position limit value" has been set to 1 and
- the encoder set in **S-0-0147, homing parameter, bit 3** is in reference (**S-0-0403, position status** = 1),

then the drive will not leave the travel range set when executing the error reaction "return motion".

**Note:** If the drive is in a position that would take it outside of the position limit values when executing a return motion, then the drive will, in this case, move to a position just in front of the relevant position limit value (precisely by **S-0-0057, Positioning window** in front of the position limit value

## Power off on error

**BB contact**

Project planning prescribes that power must be turned on via the BB contact. This means that power can only be switched on if the BB relay is closed. On the other hand, powering up requires the BB contact to open.

The signalling of a drive error to the drive package or the power supply module can be activated via parameter **P-0-0118, Power off on error** Communication utilises signal **BBdrive** (X11/5 and X11/14).

**The Structure of the Parameter:**

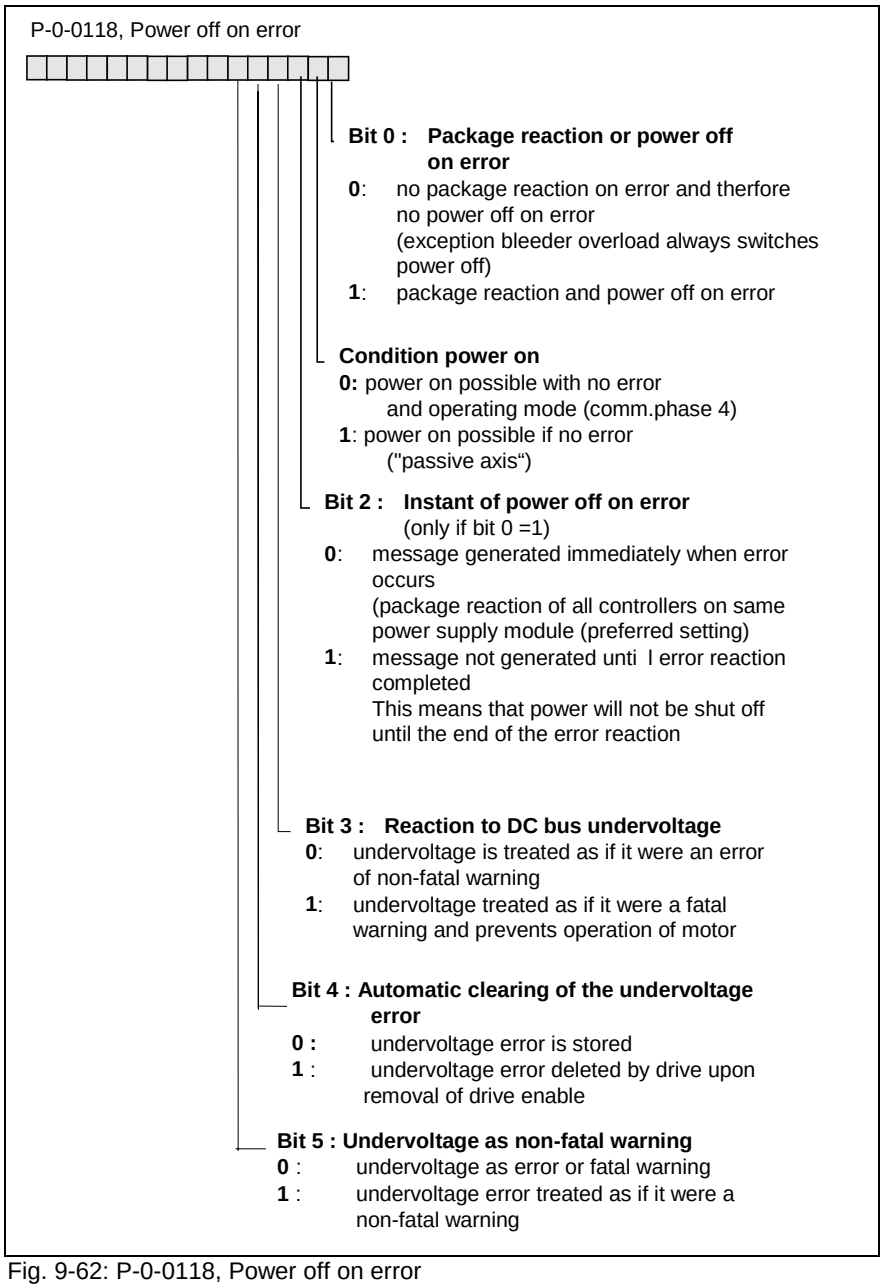

P-0-0118, Power off on error
Bit 0 : Package reaction or power off on error
0: no package reaction on error and therfore no power off on error (exception bleeder overload always switches power off)
1: package reaction and power off on error
Condition power on
0: power on possible with no error and operating mode (comm.phase 4)
1: power on possible if no error ("passive axis")
Bit 2 : Instant of power off on error (only if bit 0 =1)
0: message generated immediately when error occurs (package reaction of all controllers on same power supply module (preferred setting)
1: message not generated unti l error reaction completed This means that power will not be shut off until the end of the error reaction
Bit 3 : Reaction to DC bus undervoltage
0: undervoltage is treated as if it were an error of non-fatal warning
1: undervoltage treated as if it were a fatal warning and prevents operation of motor
Bit 4 : Automatic clearing of the undervoltage error
0 : undervoltage error is stored
1 : undervoltage error deleted by drive upon removal of drive enable
Bit 5 : Undervoltage as non-fatal warning
0 : undervoltage as error or fatal warning
1 : undervoltage error treated as if it were a non-fatal warning

Fig. 9-62: P-0-0118, Power off on error

## Power off and package reaction on error

**Signal line "BBdrive"**

In the case of drive packages (this is defined as a collection of multiple drives that have a power supply common to all and which can execute errors commonly), it is possible to inform the individual controllers and any power supply module which may be present as to whether the drive has detected an error as a result of which the power source must be shutdown. This communication utilises **signal line "BBdrive" (x11/5 and X11/14).**

If the controllers without error detect the error state on the signal line BB drive, then they will, in turn, also conduct the error reaction and shut power off.

The point in time at which the drive package is signalled (at start or end of the error reaction) is set in bit 2.

## Condition for Power On

Using bit 1 of **P-0-0118, Power off on error** it is possible to set that point in time at which the drive signals its readiness to operate and therefore at which power can be switched on.

**passive axis**

If **bit1 =** 1, then power can be switched on immediately after initialization of the drive, in other words, in communication phase 0 ("passive axis").

If **bit1 = 0**, then the drive must be in communications phase 4 and without error before the power can be switched on for the first time.

In units that cannot release energy generated during brake (by means of bleeders or a mains-regenerated power supply) bit 2 should be set to 1 to prevent the drive coasting.

## Reaction to Undervoltage (DC bus voltage too small)

Bits 3, 4 and 5 of **P-0-0118, Power off on error** offer various options on how to handle Undervoltage.

Undervoltage is present if the drive has been enabled (subject to torque) and the DC bus voltage drops below the minimum value (about 75% of the mean value of a periodic quantity).

**Undervoltage as fatal warning**

Using **Bit3 = 1** treats undervoltage as a "fatal warning".

This makes sense if the energy in the DC bus must be retained for that period of time which a control needs to start a synchronized deceleration of several drives.

The drive does not signal a class 1 diagnostics error and the reaction parametrized in **P-0-0119, Best possible deceleration** is also not conducted.

Switching the motor off leads to a slower drop in the DC bus voltage. This means that asynchronous motors can still have a magnetic field when the control starts the synchronised deceleration of the drive. Braking then takes place in generator mode.

**Automatic deleting of the undervoltage**

If undervoltage is treated as an error **(bit 3, 5 = 0),** then bit 4 can be used to set an automatic delete of the error once the control removes the drive enable signal.

This makes sense if the error occurs even with normal shutdowns and the cause is simply that the drive does not remove the enable fast enough.

**Undervoltage as warning**

Using **Bit5 = 1** it is possible to switch off every response to undervoltage in the DC bus, mains errors or mains section errors. Only one warning is generated.

**Mains error**

If either the mains section or controller detect undervoltage in the supply network (mains error), then a softstart is initiated by the mains section for the power supply (mains coupled via the bleeder resistor). If the control does not response by bringing the machine to a standstill, then in response to this warning, error **F220 Shutdown due to bleeder overload** could be generated.

# NC Response in Error Situation

*NC response during an error situation is only possible during non-fatal errors. Otherwise the drive reacts immediately with an error response.*

If the drive control device recognizes an error, it sends a message to the control (CNC) . The control can then decelerate the servo axis of the machine, thus preventing damage.

If this is desired, you have to delay the drive error reaction to allow the axis to continue movement to the values set by the control. This is achieved by setting the time delay between the recognition of the error and the drive's error reaction. This can be set in parameter **P-0-0117, NC Reaction on Error**.

The following applies:

| Value of P-0-0117 | Function |
|---|---|
| 0 | Drive proceeds the error reaction immediately after recognition of an error. |
| 1 | Drive continues for 30 sec in the selected operating mode, then follows the "best possible deceleration". |

Fig. 9-63: NC Reaction on Error

**Note:** Activating the "NC Reaction on Error" is only recommended for controls that have a corresponding error reaction procedure.

# Emergency stop feature

The E-Stop function supports the braking of the drive via a hardware input on the drive controller. It thus represents the option of shutting down the drive parallel to command communication, in an emergency.

Activation and how to set the deceleration is parametrizable.

The following parameters are used:

- **P-0-0008, Activation E-Stop function**
- **P-0-0223, Status Input E-Stop function**

## Functional principle of the E-Stop function

By activating the E-Stop function (bit 0 = 1) the drive executes, upon actuation of the E-stop input, the selected reaction for deceleration. This reaction depends on bit 2 of P-0-0008.

**Interpretation as warning E834 Emergency-Stop active**

If the interpretation "fatal warning" has been parametrized there (bit 2 = 1), then the drive responds by switching off the external drive enable with the reaction parametrized in **P-0-0119, Best possible deceleration**. The warning diagnosis **E834 Emergency-Stop** appears. Bit 15 is set in **S-0-0012, Class 2 diagnostics** (manufacturer specific warning). Simultaneously, the bit "change bit class 2 diagnostics" is set in the drive status word. This change bit is cleared by reading **S-0-0012, Class 2 diagnostics.**

The functional principle at work when actuating the E-Stop input is that of a series connection to an external drive enable. When activating the E-Stop input, the drive responds as if the external drive enable switched off.

To re-activate the drive, the E-Stop input must become inactive, and another 0-1 edge must be applied to the external drive enable.

**Interpretation as error with adjustable reaction**

If bit 2 has been set to treat it as an error, then the reaction selected in bit 1 is performed. The error diagnosis **F434 Emergency-Stop** (or **F634 Emergency-Stop**), E-stop activated appears, and bit 15 is set in parameter **S-0-0011, Class 1 diagnostics** . Bit 13 is set in the drive status word of the drive telegram, i.e., drive interlock, error with class 1 diagnostics is set. The error can be cleared via command **S-0-0099, C500 Reset class 1 diagnostic, or** the S1 button on the drive controller if the E-stop input is no longer activated.

This function basically works as if an error had occurred in the drive. The drive reaction is immediate, independent of p**arameter** P-0-0117, **NC reaction on error**.

**F434 Emergency-Stop active**

If bit 1 = 0, the drive shuts down according to **P-0-0119, Best possible deceleration**. The diagnosis upon activating the E-stop input then reads **F434 Emergency-Stop.**

**Interpretation as error with reaction as "Velocity command value to zero"**

## Status of the Emergency-Stop Input

If bit 1 is set to 1 , then the drive is braked at maximum torque, if an E-Stop of the drive is triggered, until the speed = 0, regardless of the error reaction set in parameter P-0-0119. This corresponds to the best possible standstill "Velocity command value to zero". The diagnosis with the activation of the E-Stop input then reads **F434 Emergency-Stop.**

The state of the E-Stop input can be controlled via parameter **P-0-0223, Status Input E-Stop function**. The state of the E-stop input is stored there in bit 0.

## Activation and Polarity of the E-Stop Input

For the activation of the E-Stop input and the selection of a response for shutdown of the drive, use parameter **P-0-0008, Activation E-Stop function**.

The following applies:

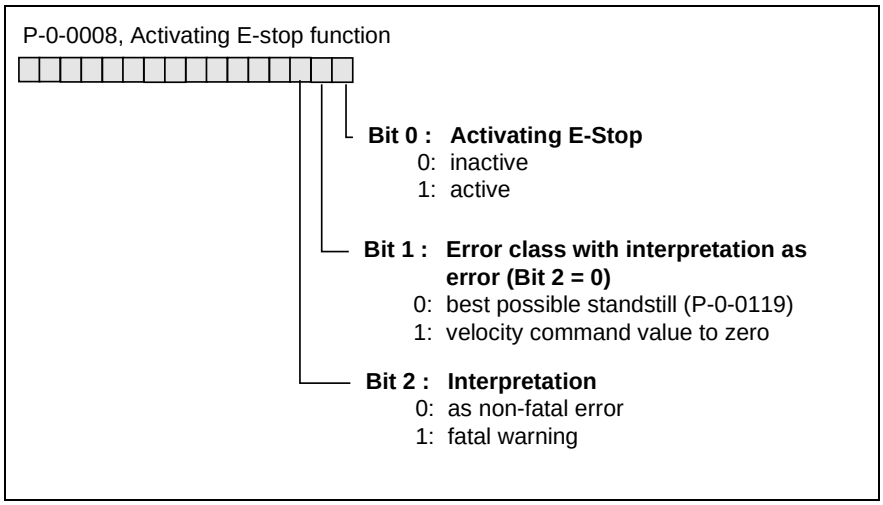

P-0-0008, Activating E-stop function
Bit 0 : Activating E-Stop
0: inactive
1: active
Bit 1 : Error class with interpretation as error (Bit 2 = 0)
0: best possible standstill (P-0-0119)
1: velocity command value to zero
Bit 2 : Interpretation
0: as non-fatal error
1: fatal warning

Fig. 9-64: P-0-0008, Activation of E-Stop-Function

## Connection of the Emergency-Stop Input

see project planning manual.

# 9.7 Control Loop Settings

## General Information for Control Loop Settings

The control loop settings in a digital drive controller are important for the characteristics of the servo axis.

*"Optimizing" the regulator settings is generally not necessary!*

Determining the control loop settings requires expert knowledge. For this reason, application-specific control parameters are available for all digital Rexroth Indramat drives. These parameters are either contained in the feedback data memory and can be activated through the command **S-0-0262, C700 Command basic load** (with MHD, MKD and MKE motors) or they must be input via the setup/service program. (See also "Load Default Feature")

In some exceptions, however, it may be necessary to adjust the control loop settings for a specific application. The following section gives a few simple but important basic rules for setting the control loop parameters in such cases.

In every case, the given methods should only be seen as guidelines that lead to a robust control setting. Specific aspects of some applications may require settings that deviate from these guidelines.

The control loop structure is made up of a cascaded (nested) **position, velocity and torque/force loop**. Depending on the operating mode, sometimes only the torque control loop or the torque and velocity control loops become operative. The control is structured as depicted below:

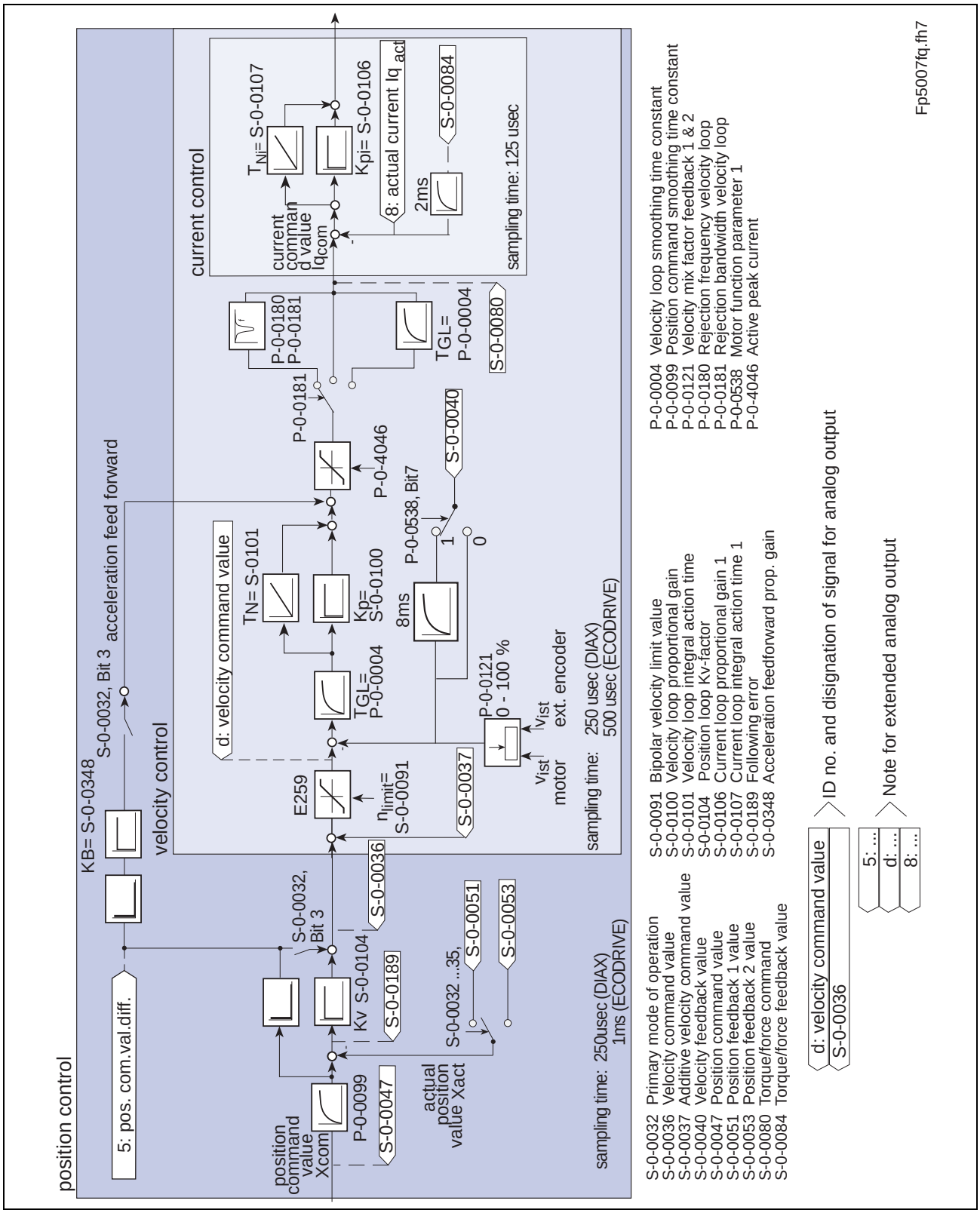



Fig. 9-65: Control structure

# Load Default

With the command **Basic Load**, you can activate the default control parameters for motor types with **motor feedback data memory** such as

- MHD
- MKD
- MKE

With these parameters, the relevant control parameters can be set for the motor type used.

---

**Note:** The parameters are pre-defined by the manufacturer for the moment of inertia relationship of $J_{motor} = J_{load}$.

---

Most applications can work with these values.

**Default values** can be set for the following parameters:

- **S-0-0100, Velocity loop proportional gain**
- **S-0-0101, Velocity loop integral action time**
- **S-0-0104, Position loop Kv-factor**
- **S-0-0106, Current loop proportional gain 1**
- **S-0-0107, Current loop integral action time 1**
- **S-0-0348, Acceleration feedforward gain**
- **P-0-0004, Smoothing Time Constant**
- **P-0-0181, Rejection bandwidth velocity loop**

The feature **Load Default Settings** can be activated in two different ways:

- Automatic activation during the command procedure **S-0-0128, C200 Communication phase 4 transition check** for the first operation of this motor type with this drive.
- With the command procedure **S-0-0262, C700 Basic Load**

## Automatic Execution of the Load Default Feature

If a controller has been operated with a specific type of motor, then the controller will detect this from that point forward. During the execution of command **S-0-0128, C200 Communication phase 4 transition check** it compares parameter **S-7-141, Motor type**, which is read out of the data memory, with the value for parameter **S-0-0141, Motor type** which is backed up in the parameter memory of the controller. If these two parameters are different, then error **F208 UL The motor type has changed** is generated. "UL" appears in the 7-segment display.

---

**Note:** Before the user can reset the error and thus start the base load function, the option of saving a specific set of controller parameters is available.

---

Error **F208 UL The motor type has changed** can be reset in three different ways:

1.) executing the command
**S-0-0099, C500 Reset class 1 diagnostic**

2.) Actuating key S1

3.) Applying 24 V at error reset input

In all three cases, the load base values function is activated.

If the execution of load base values is not possible, then the relevant command error of command **S-0-0262, C700 Command basic load** will appear**.**

(See also section: "Error Conditions of the Load Default Settings Procedure").

### Run the Load Default Settings feature as a command

With parameter **S-0-0262, C700 Basic load**, the feature can be run as a command. This might be useful if manually changed control parameters are to be set back to the default values.

### Error Conditions of the Load Default Settings Procedure

If the function started by running the command **S-0-0262, C700 Basic load** is not successfully processed, then the reason for this error is displayed either on the 7-segment display or with the diagnostic parameter **S-0-0095**.

The following could cause an error during basic load:

| SS Display | Diagnostic Message: | Cause: |
|---|---|---|
| C702 | Default parameters not available | Basic load (or load defaults) is impossible for the motor type selected, load defaults is only possible for MHD-, MKD and MKE |
| C703 | Default parameters invalid | Connection of drive to motor encoder data memory is interrupted or feedback is defective |
| C704 | Parameters incorrect | The existing default value cannot be processed since, for example, the extreme value limit was exceeded in the default value |

Fig. 9-66: Possible errors during Basic Load command

**Note:** If a parameter can not be set to its default value, the parameter is set invalid in its data status. This serves safety purposes and helps in diagnosing errors.

## Setting the Current Controller

The parameters for the current loop are set by Rexroth Indramat and cannot be adjusted for specific applications. The parameter values set at the factory are activated with the command **S-0-0262, C700 Command basic load** for MKD/MHD motors or must be retrieved from the motor data sheet.

The parameters for the current controller are set via the parameters

- **S-0-0106, Current loop proportional gain**
- **S-0-0107, Current Loop Integral Action Time**

Warning

**Changing the values defined by Rexroth Indramat**
can result in damages to the motor and the drive controller.
⇒ Changes to the current controller parameters are not permitted.

# Setting the Velocity Controller

**Pre-requisites:** The current control must be correctly set.

The velocity controller is set via the parameters

- **S-0-0100, Velocity Loop Proportional Gain**
- **S-0-0101, Velocity Loop Integral Action Time**
- **P-0-0004, Smoothing Time Constant**

as well as the parameters

- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

The setting can be made by:

- conducting the load base values function once
- in accordance with the procedure described below
- by starting the command "automatic control loop settings"

## Preparations for Programming the Velocity Controller

A number of preparations must be made in order to be able to set the velocity loop (controller):

- The mechanical system must be set up in its final form in order to have actual conditions while setting the parameters.
- The drive controller must be properly connected as described in the user manual.
- The safety limit switches must be checked for correct operation (if available)
- The "Operating Mode: Velocity Control" must be selected in the drive.

**Start settings** The controller setting must be selected for the start of parameterization as follows:

**S-0-0100, Velocity Loop Proportional Gain** = default value of the connected motor.

**S-0-0101, Velocity Loop Integral Action Time** = 6500 ms (no integral gain)

**P-0-0004, Smoothing Time Constant** = Minimum value (= 500µs) ➔ Filter is switched off

**P-0-0181, Rejection bandwidth velocity loop** = 0 Hz (deactivated)

## Definition of the Critical Proportional Gain and Smoothing Time Constant

- After turning on the controller enable, let the drive move at a low velocity. Rotational motors: 10...20RPM, linear-Motors: 1...2 m/min)
- **Raise the S-0-0100, Velocity loop-proportional gain** until unstable behavior (continuous oscillation) begins.
- Determine the frequency of the oscillation by oscilloscoping the actual velocity (see also "Analog Output"). If the frequency of the oscillation is much higher than 500Hz, raise the **P-0-0004, Smoothing Time Constant** until the oscillation ends. After this, increase the **S-0-0100, Velocity Control Proportional Gain** until it becomes unstable again.
- **Reduce the S-0-0100, Velocity loop proportional gain** until the oscillation ends by itself.

The value found using this process is called the "**critical velocity loop proportional gain".**

---

**Note:** By inputting **P-0-0181, Rejection bandwidth velocity loop** = -1 a $PT_2$ filtering can be activated. (See also Control structure in chapter: "General Information for Control Loop Settings").

---

## Determining the Critical Integral Action Time

1. Set **S-0-0100, Velocity loop proportional gain** = 0.5 x critical proportional gain
2. Lower **S-0-0101, Velocity loop integral action time** until unstable behavior results.
3. Raise **S-0-0101, Velocity loop integral action time** until continuous oscillation vanishes.

The value found using this process is called the "**Critical Integral Action Time."**

## Determining the Velocity Controller Setting

The critical values determined before can be used to derive a control setting with the following features:

- Independent from changes to the axis since there is a large enough safety margin to the stability boundaries.
- Safe reproduction of the characteristics in series production machines.

The following table shows many of the most frequently used application types and the corresponding control loop settings.

| Application Type: | Velocity controller proportional gain | Velocity loop Integral Action Time: | Comments: |
|---|---|---|---|
| Feed axis on standard tool machine | Kp = 0.5 • Kpcrit | Tn = 2 • Tncrit | Good stiffness and good command response |
| Feed axis on perforating press or chip-cutter machines | Kp = 0.8 • Kpcrit | Tn = 0 | High proportional gain; no I-part, to achieve shorter transient periods. |
| Feed drive for flying cutting devices | Kp = 0.5 • Kpcrit | Tn = 0 | Relatively non-dynamic control setting without I-part, to avoid structural tension between the part to cut off and the machine. |

Fig. 9-67: Identification of Velocity Controller Settings

## Filtering oscillations from mechanical resonance

The drives are able to suppress oscillations caused by the drive train (gear) between the motor and the axis or by the spindle mechanics even in a narrow band. Thus, an increased drive dynamics with good stability can be achieved.

The mechanical system of rotor-drive train-load is induced to generate mechanical oscillations as a result of position/velocity feedback in a closed control loop. This behavior identified as a "two mass oscillator" is generally within the 400 to 800 Hz range, depending on the rigidity (or elasticity) and spatial volume of the mechanical system.

This "two mass oscillation" usually has a clear resonance frequency which can be specifically suppressed by a notch filter (band suppressor) provided in the drive.

By suppressing the mechanical resonance frequency the dynamics of the velocity and position control loops in terms of control can be significantly improved compared to without a band suppression filter.

This results in greater contour accuracy and smaller cycle times for positioning processes, leaving sufficient stability margin.

The rejection frequency and bandwidth can be set. The rejection frequency is the one with highest attenuation, the bandwidth determines the frequency range, at whose borders the attenuation is 3dB less. Greater bandwidth leads to smaller band attenuation of the center frequency!

The following parameters can be used to set both:

- **P-0-0180, Rejection frequency velocity loop**
- **P-0-0181, Rejection bandwidth velocity loop**

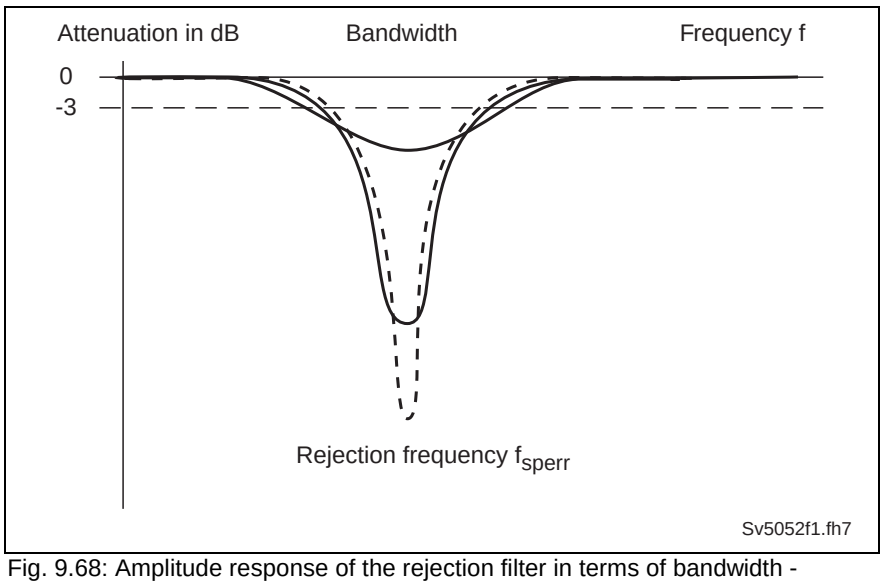



Fig. 9.68: Amplitude response of the rejection filter in terms of bandwidth - qualitative

To set the band filter, we recommend the procedure described as follows:

**Pre-settings**

Set rejection filter inactive. Set 0 in parameter **P-0-0181 Rejection bandwidth velocity loop.**

**Determing resonance frequency**

Connect oscilloscope to analog output channels. Assign velocity feedback value to analog output 1 (in **P-0-0420, Analog output 1, signal selection** "S-0-0040" and in **P-0-0422, Analog output 1 scaling** enter the scaling, e.g., 100 rpm / 10 volts.

**- or -**

Use the oscilloscope function of the drive to display velocity feedback value. This can be read out directly by an FFT of the frequency response.

Excite the drive mechanics, e.g., tap lightly with a rubber hammer.

Record the time of the velocity oscillations with an oscilloscope or oscilloscope function and analyze the clearly salient frequencies. If the oscilloscope function is used, then the resonance frequency can be directly read out of the frequency readout.

**Determining the initial state of the loop**

Set the drive enable signal and optimize the velocity loop with inactive rejection filter (see "Setting the Velocity Controller").

Record step response of the velocity feedback and the torque/force generating command current with a small velocity command step. (The torque-generating command current is not allowed to reach the limit during this process.)

**Turn rejection filter on and check the effect**

Enter the most salient frequency in Hz in parameter **P-0-0180, Rejection frequency velocity loop.**

Enter a minimum bandwidth in parameter **P-0-0181, Rejection bandwidth velocity loop,** e.g., 25 Hz.

Record the previous step response again.

**If the step response features less overshoot and shorter periods of oscillation, then:**

Check whether increasing the value of **P-0-0181, Rejection bandwidth velocity loop** causes an improvement

**- or -**

check whether a change in the value of **P-0-0180, Rejection frequency velocity loop** means an improvement.

**If the step response results in the same behavior, then:**

Check the resonance frequency analysis

**- or -**

clearly increase the value in **P-0-0181, Rejection bandwidth velocity loop.**

**Optimize rejection filter or velocity loop**

with the pre-optimized values of **P-0-0180, Rejection frequency velocity loop** and **P-0-0181, Rejection bandwidth velocity loop,** optimize the velocity controller again (see above).

> The step responses defined above must have a similar appearance with higher values for **S-0-0100 Velocity loop proportional gain** and / or smaller values for **S-0-0101 Velocity loop integral action time.**

An additional optimizing run may be necessary for P-0-0180 Rejection frequency velocity loop and P-0-0181, Rejection bandwidth velocity loop using the step response (see above).

**Filtering with double smoothing filter**

Optimization of the control loop with a notch filter (band suppression) does not always make the regulation good enough. This happens for example when the closed loop does not have significant resonance frequencies. Activation of a second smoothing filter (with low pass response) can, depending on the case, improve the regulation quality as desired.

To do this, set the parameter **P-0-0181, Rejection bandwidth velocity loop** to **-1**. The notch filter as well as the assigned parameter **P-0-0180, Rejection frequency velocity loop** are deactivated. Instead of the notch filter, a smoothing filter is activated in the control loop. This uses the same smoothing time constant $T_{gl}$ as the smoothing filter with **P-0-0004 Velocity loop smoothing time constant**. Together with the smoothing filter at the input of the velocity controller, you obtain a low pass filter of 2nd order (2 poles). Frequencies greater than the cut-off frequency $f_g = 1/2\pi T_{gl}$ are much more suppressed and cannot excite oscillations in the control loop any more. The parameter for the filter is **P-0-0004 Velocity loop smoothing time constant**.

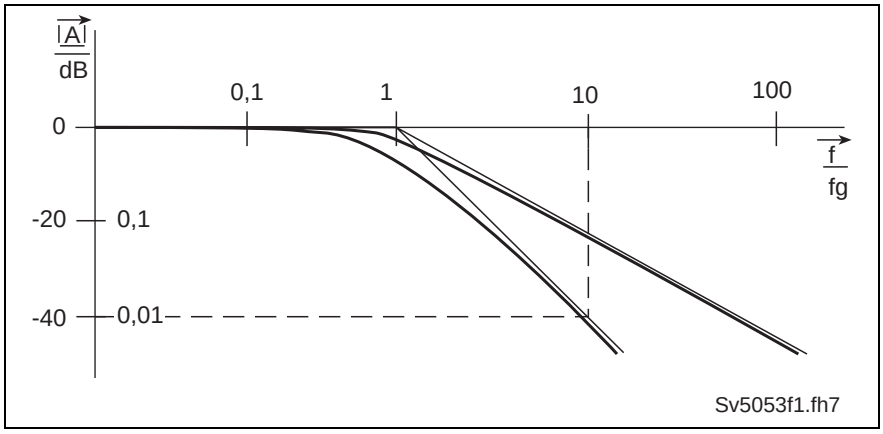



Fig. 9-69: Frequency response of low pass filters with 1 pole and with 2 poles

**Note:** The adjustment is the same as described under "Definition of the Critical Proportional Gain and Smoothing Time Constant".

## Velocity Control Loop Monitoring

If the velocity control loop monitor detects a fault in the velocity control loop then error

- **F878 Error in velocity control loop**

is generated.

**Note:** The velocity control loop monitor is only active if an operating mode is active with which the velocity control loop in the drive is closed and monitoring activated (always except with torque control).

### Activating the monitor

The monitor is activated with parameter **P-0-0538, Motor function parameter 1**.

**The structure of the parameter:**

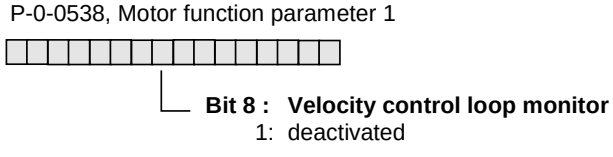



Fig. 9-70: P-0-0538, Motor function parameter 1

See also the parameter description: **P-0-0538, Motor function parameter 1**.

**Note:** It is highly recommended not to deactivate the velocity control loop monitor activated at the factory as it represents a basic safety function of the drive!

### The causes of a monitor trigger

The velocity control loop monitor is designed to monitor for those faults that could lead the motor torque in the wrong direction.

The following options are basically possible:

- incorrect poles with motor connection
- wrong commutation angle
- faults in the velocity encoder

**Note:** This prevents the "runaway effect" of the motor.

### Criteria for Triggering the Monitor

The following criteria must be met for the velocity control loop monitor to be triggered :

- Current command value limited by **P-0-4046, Active peak current**
- motor accelerating in the wrong direction
- and actual velocity control value is > 0.0125*$n_{Max}$

## Setting the position controller

**Pre-requisite:** Current and speed control must be correctly set.

The position controller can be set with the parameter

- **S-0-0104, Position Controller Kv Factor**

This can be set by either executing the load default settings procedure or by following the process below.

### Preparations for Setting the Position Control Loop

A number of preparations must be made in order to be able to set the position controller properly:

- The mechanical system must be completely assembled and ready for operation.
- The drive controller must be properly connected as described in the user manual.
- The safety limit switches must be checked for correct operation (if available)
- Operate the drive in a mode that closes the position loop in the drive (Operating Mode: Position Control").
- The velocity controller must be properly tuned. The start value chosen for the $K_v$-factor should be relatively small ($K_v$ = 1).
- For the determination of the position controller parameter, no compensation function should be activated.

### Determining the Critical Position Controller Gain

- Move axis at a slow velocity, i.e., with a jog function at a connected NC Control (Rotating Motors: 10...20 Rpm, linear-Motors: 1...2m/min).
- Raise the $K_v$-factor until instability appears.
- Reduce the $K_v$-factor until the continuous oscillation ends by itself.

The Kv factor determined through this process is the "**Critical position control loop gain".**

### Determining the Position Controller Setting

In most applications, an appropriate position controller setting will lie between 50% and 80% of the critical position controller loop gain.

This means:

**S-0-0104, Position Loop KV-Factor** = 0.5..0.8 • Kvcrit

## Position Control Loop Monitoring

The position control loop monitor helps to diagnose errors in the position control loop.

Reasons for errors in the position control loop can be:

- Exceeding the torque or acceleration capability of the drive.
- Blocking of the axis' mechanical system
- Disruptions in the position encoder

The monitoring of the position circuit is only active when an operation mode with closed position loop is active in the drive.

To set and check the monitoring function, two parameters are used:

- **S-0-0159, Monitoring Window**
- **P-0-0098, Max. Model Deviation**

If the drive detects an error in the position control loop, the error message

- **F228 Excessive deviation**

is issued.

### General Operating Characteristics of Position Control Loop Monitoring

To monitor the position control loop, a model actual position value is computed, which depends only on the commanded position profile and the set position loop parameters. This model position is compared continuously to the actual position. If the deviation exceeds **S-0-0159, Monitoring Window** for more than **8msec**, an error **F228 Excessive deviation** will be generated.

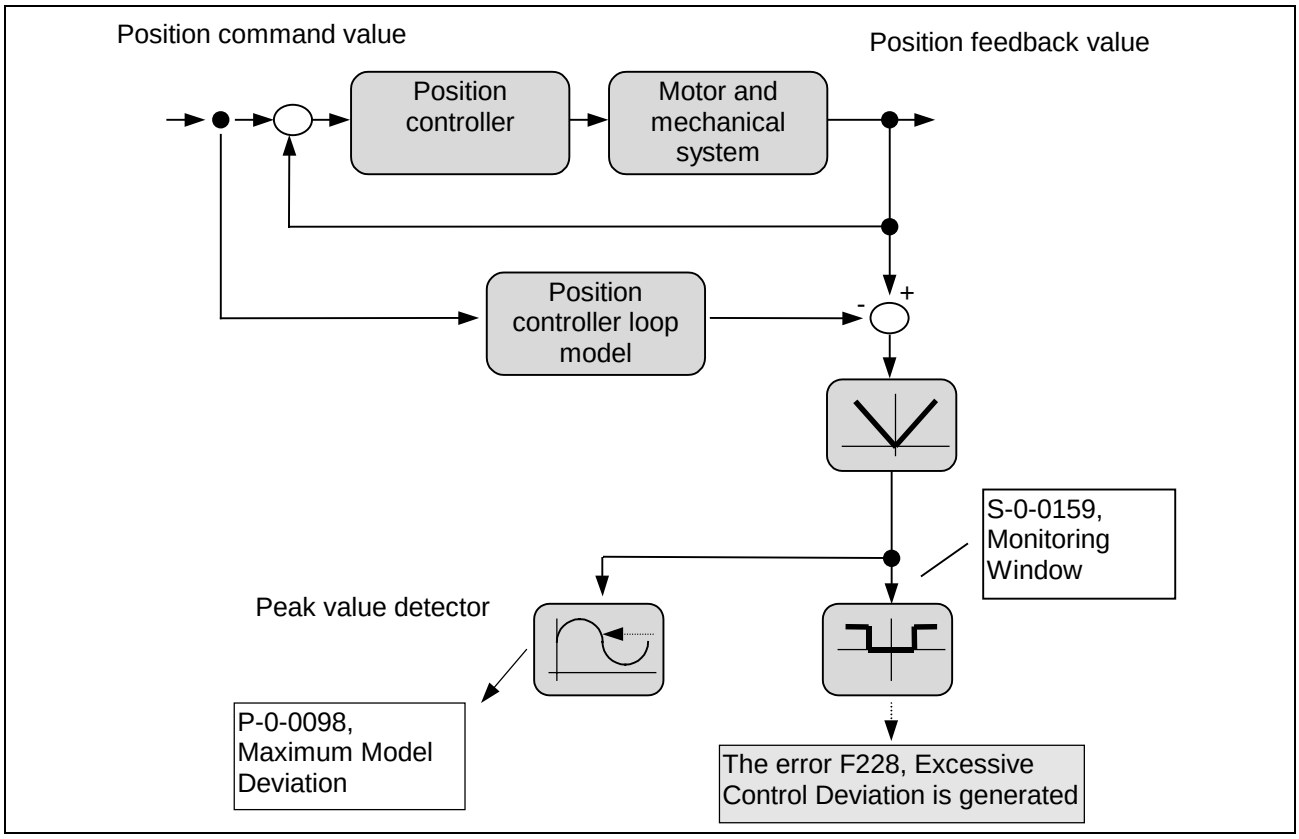



Fig. 9-71: Schematic of Position Control Loop Monitoring

**Note:** For accurate monitoring, the actual feedback value from the position control is always used. This means that for position control with the motor encoder, position feedback value-1 is used; and for position control with the external encoder, the position feedback value-2 is used.

## Setting the Position Control Loop Monitor

**Requirements** Requirements for the setup of the position loop monitoring are

- Check the velocity and position control loops for their appropriate settings.
- The axis in question should be checked mechanically and should be in its final state.

**settings** The position control loop monitor settings are performed:

- Through the connected control, you should proceed in a typical operation cycle. In this mode, move at the maximum projected velocity.
- In parameter **P-0-0098, Max. Model Deviation**, the maximum deviation between the actual feedback value and the expected feedback value is always displayed. (Note: The contents of this parameter are not saved. After enabling the drive, this parameter equals zero.)
- This value can be used to help set the monitoring window. Parameter **S-0-0159, Monitoring Window** should be set to **P-0-0098, Max. Model Deviation** multiplied by a safety factor. A safety factor between 1.5 and 2.0 is recommended.

**Example:**

Content of P-0-0098, Maximum Model Deviation:

0.1 °

⇒ Determination for the parameter S-0-159, Monitoring Window:

0.2 ° (= 2 x 0.1 °)

### Deactivation of the Position Control Loop Monitoring

It is strongly recommended to activate the position loop monitoring. However, there are exceptions for which the position loop monitoring must be deactivated. You can do that with the parameter **S-0-0159, Monitoring Window**, if it is set to very high values.

**Note:** By default, the Position Control Loop Monitoring is active.

## Setting the Acceleration Feed Forward

For Servo applications, where high precision at high speeds counts, you have the option to greatly improve the precision of an axis during acceleration and brake phases through activation of the acceleration feed forward.

Typical applications for the use of the acceleration feed forward:

- Free form surface milling
- Grinding

To set the acceleration feed forward, use the parameter

- **S-0-0348, Proportional Gain Acceleration Feed Forward**

This value can be determined as follows.

### Requirements for a Correct Setting of the Acceleration Feed Forward

- Velocity and position loop have to be set appropriately.
- For the "Position Controller", a **lagless** operation mode must be selected.

### Setting the Acceleration Feed Forward

Setting the correct acceleration feedforward can only be done by the user since it depends on the inertia.

**Note:** With automatic control loop settings it is not only possible to determine inertia but also the value for S-0-0348.

The setting is done in two steps:

- Calculation of the preset value for the acceleration feedforward. For this purpose, you need the size of the complete inertia momentum translated to the motor shaft ( $J_{Motor}+J_{Load}$ ) of the axis. This value is known approximately from the size and set-up of the load. Additionally, you need the torque constant of the used motor. This data can be retrieved from the motor data sheet or the parameter **P-0-0051, Torque-/Force Constant** Kt. The preset value is calculated as:

$$\text{AccelerationFeedforward} = \frac{J_{Motor} + J_{Load}}{Kt} \times 1000$$

Acceleration Feedforward [mA/(rad\s²)]
J*Motor*: Inertia momentum of the motor [kg m²] (P-0-0510)
J*Load*: Inertia momentum of the load [kg m²] (P-0-4010)
Kt: Torque constant of the motor [Nm/A] (P-0-0051)

Fig.9-72: Value for the Acceleration Feedforward

The determined value is entered in parameter **S-0-0348, Acceleration Feedforward prop. Gain**.

**Checking the effect of the acceleration feedforward** and, if necessary, **fine tuning** of the parameter **S-0-0348, Acceleration Feedforward prop. Gain**:

The deviation of the actual feedback value to the position command can be displayed through the analog diagnostic output of the drive controller or the oscilloscope function. To check the effect of the acceleration feed forward, you must oscilloscope the signal during movement of the axis along the desired operation cycle. In acceleration and brake phases, the feedforward must reduce the control deviation drastically.

## Setting the Velocity Mix Factor

With the help of the velocity mix factor, you can combine the velocity feedback value, used for velocity control, from the motor and the external measurement system. This might be an advantage, when there is play or torsion between motor and load.

To set the mixing ratio, use the parameter

- **P-0-0121, Velocity Mixfactor Feedback1 & 2**

**Precondition:** The function is only applicable when there is an external measurement system. If this is not available, **P-0-0121** is automatically set to 0 % .

The mixture of the velocity feedback value can be continuously varied between:

- 100% Velocity feedback value of the motor encoder
  /
  0% actual value of the external encoder (P-0-0121 = 0)
  and
- 0% Velocity feedback value of the motor encoder
  /
  100% actual value of the external encoder (P-0-0121 = 100 %)

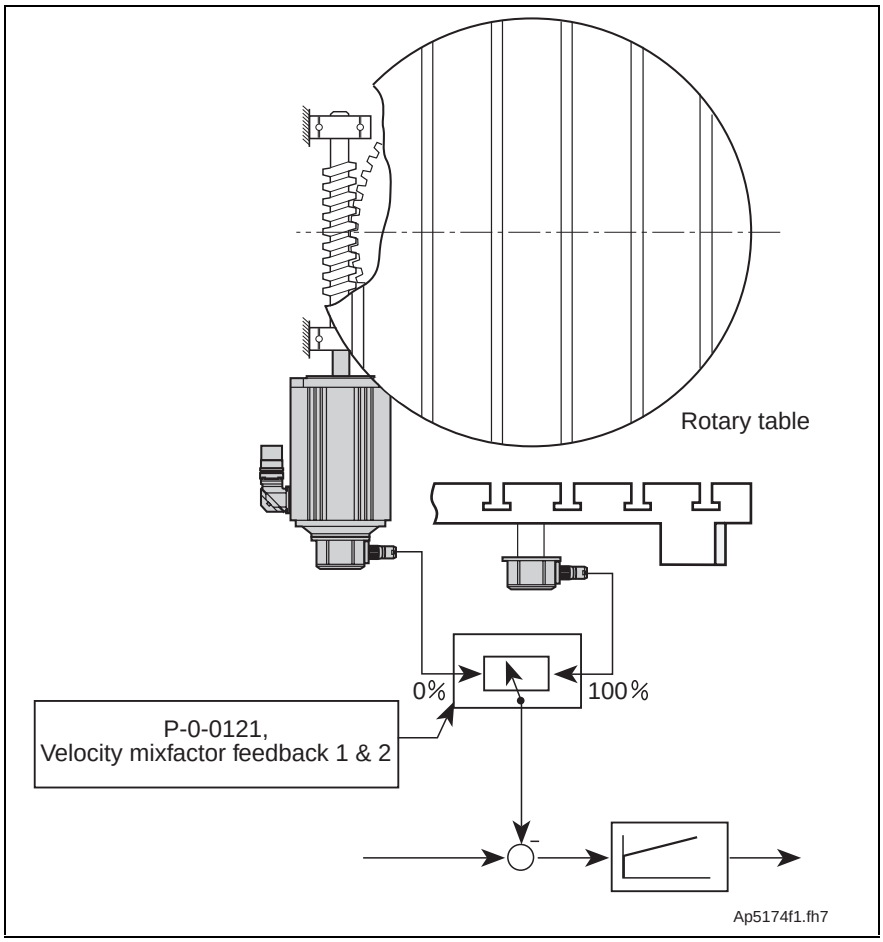



Fig. 9-73: Velocity Mixture Diagram

# 9.8 Automatic Control Loop Settings

## General Comments

To expedite drive parametrization, the firmware offers an automatic control loop setting. Using parameters **P-0-0163**, **Damping factor for automatic control loop adjust** and **P-0-0164**, **Application for automatic control loop adjust**, it is possible to control (control loop dynamics) the results.

**Note:** It is necessary **to move the drive** in order to conduct the automatic control loop settings. The velocity and position control loops are optimised!

## Prerequisites for starting the automatic control loop settings

**WARNING**

⇒ Check and make sure that the emergency stop travel range limit switch is working.

See section: "Safety Instructions for Electric Servo Drives and Controls".

⇒ During the command **D900 Command automatic loop tuning,** the drive conducts its own external command value programmed motions.

## Definition of travel range for control loop settings

Since the axis must be moved in order to identify and set the control loop, it is necessary to define a travel range. There are two options:

- Define a travel range by inputting the limits, **P-0-0166, Lower position limit for automatic control loop adjust** and **P-0-0167, Upper position limit for automatic control loop adjust** (a downwardly-compatible function).
- Input **P-0-0169**, **Travel distance for automatic control loop adjust** (needed with modulo axes!)

---

**Note:** The mode is selected with the use of parameter **P-0-0165, Selection for automatic control loop adjust**.

---

**Inputting the limits P-0-0166, P-0-0167**

If bit15 of P-0-0165 has not been set, then the range in which the axis may move with an automatic control loop setting is defined with

- an upper limit position **P-0-0166**
- and a lower limit position **P-0-0167**

This results in the value of **P-0-0169, Travel distance for automatic control loop adjust.**

**Inputting P-0-0169, Travel range for automatic controller settings**

If **Bit 15** of **P-0-0165 is set,** then the range in which the axis may move with an automatic control loop setting is defined with

- **P-0-0169, Travel distance for automatic control loop adjust** and
- **Start position** (actual position) **at the start of a command**

This results in the value of **P-0-0166,** lower limit for automatic CL (start position - travel range) and of **P-0-0167**, upper limit for automatic CL (start position + travel range) in which the axis may move to execute the command.

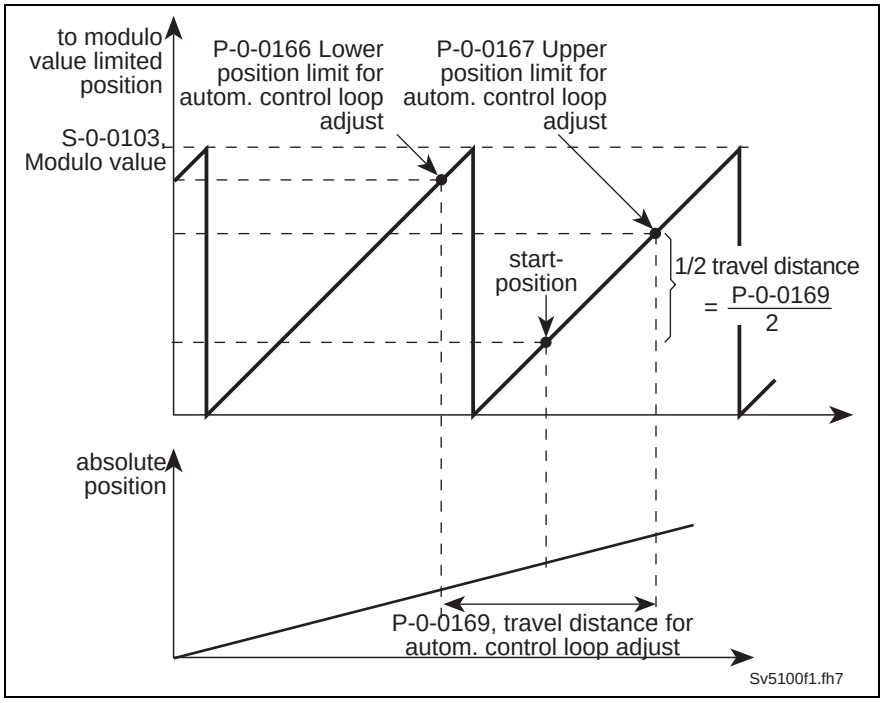

to modulo value limited position
P-0-0166 Lower position limit for autom. control loop adjust
P-0-0167 Upper position limit for autom. control loop adjust
S-0-0103, Modulo value
start-position
1/2 travel distance
= P-0-0169 / 2
absolute position
P-0-0169, travel distance for autom. control loop adjust
Sv5100f1.fh7

Fig. 9-74: Travel range with automatic control loop settings with modulo scaling

**Note:** The travel range defined here is only monitored during the time that the command is being executed.

**Possible errors:**

**D905 Position range invalid, P-0-0166 & P-0-0167**

If the defined travel path equals less than two motor revolutions, then command error **D905 Position range invalid, P-0-0166 & P-0-0167** will be generated.

**D906 Travel range exceeded**

If the axis is not within the above defined range at the start of the command, then command error **"D906 Position range exceeded"** is generated.

## Control loop settings

Before executing the command, set the default control parameters stored in the motor feedback.

## Drive enable or drive start

The oscillations and thus the automatic control loop settings are only conducted if

- the **drive enable** is present

  **and**

- **drive start** is issued.

**Note:** If there is no drive enable at command start, then command error **D901 Start requires drive enable** is generated

## Command settings

All parameters used in the execution of the command must be programmed before command start so that they are effective in the automatic control loop setting.

- **P-0-0163, Damping factor for automatic control loop adjust**
  Use this parameter to select the desire control loop dynamics.
- **P-0-0164, Application for automatic control loop adjust** helps taking the mechanical conditions with controller optimization into account.
- **P-0-0165, Selection for automatic control loop adjust**
  Used to select functinalities (modes) of the automatic control loop settings.

**Possible causes for command errors: "D903 Inertia detection failed"**

- **S-0-0092, Bipolar torque/force limit value**
  The maximum torque for the automatic control loop settings can be programmed with parameter **S-0-0092, Bipolar torque/force limit value**. This can help limit the torque to prevent mechanical wear and tear.
- **S-0-0108, Feedrate override**
  The velocity of the automatic control loop settings can be programmed via the analog channel (Poti) with this parameter.
- **S-0-0259, Positioning Velocity**
  This sets the speed for the control loop settings. If the value is not high enough, the command error D903 is generated.
- **S-0-0260, Positioning Acceleration**
  The maximum positioning speed is set here. If the value is not high enough, then command error D903 is generated.

**Note:** The reasons that command error **D903 Inertia detection failed** is generated can either be an excessive inertia, a too slow speed, acceleration or torque.

# Conducting Automatic Control Loop Settings

**Note:** **1)** The execution of the settings is connected with a drive motion. This means that the drive moves in terms of the travel range fixed in parameters P-0-0166 and P-0-0167 or P-0-0169.
**2)** The parameter settings needed to conduct the command must be generated prior to command start.

## Start command

Initiated by writing into parameter **P-0-0162, D900 Command Automatic control loop adjust** with binary numeric value 3 (11b) (=command start).

## Tripping a motion

An axis motion and thus the execution of a setting is only possible if the signal **Drive halt** has not been set.

Otherwise, **D900 Command automatic loop tuning** at the appears in the display start of the command and the axis does not move.

**Triggering a motion by starting command D900**

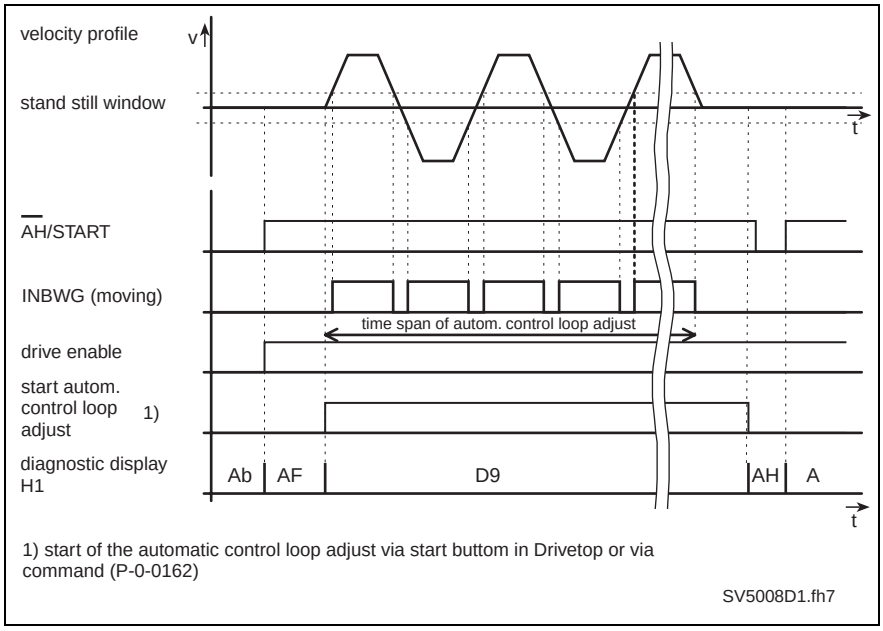



Fig. 9-75: Signal flow chart

**Triggering motion with drive start**

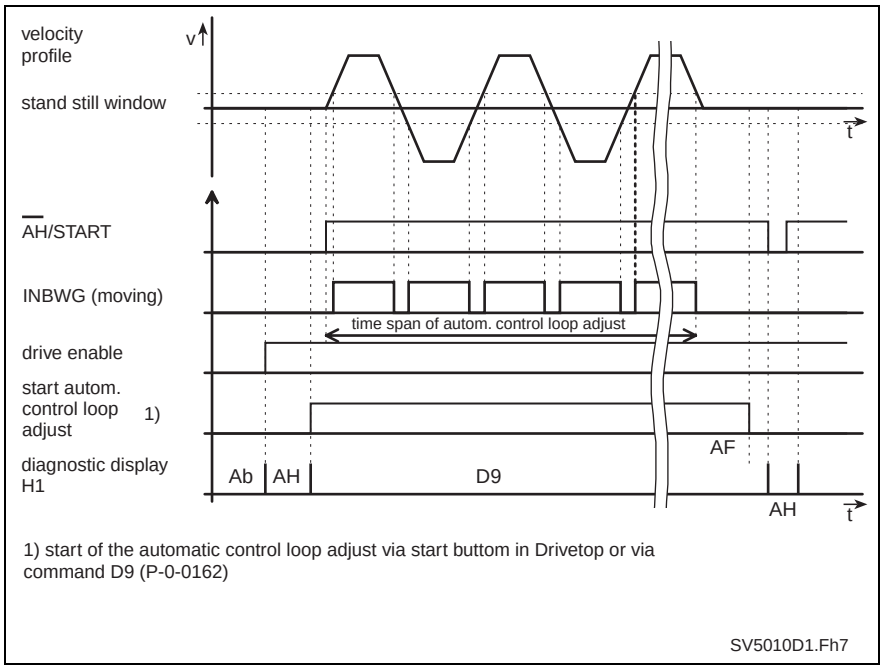



Fig. 9-76: Signal flow chart

**Terminating command with drive halt**

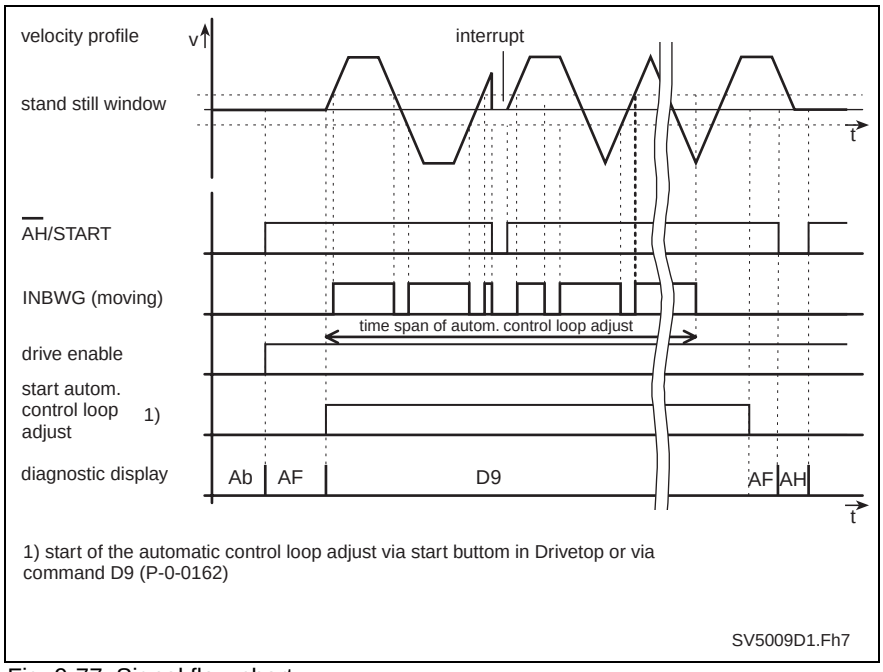



Fig. 9-77: Signal flow chart

**Note:** A further run with change settings can be conducted either:
1) by removing and then applying the drive enable or start signal (drive start)
2) or by ending and then restarting command D900

# Chronological Sequence of Automatic Control Loop Settings

## Sequence:

**1st step:** Check for command errors at command start.

**2nd step:** **Determine total and extrinsic inertia** by evaluating accel and decel procedures.

**3rd step:** **Calculate** and use **controller parameters** in drive.

The Parameters **P-0-0163, Damping factor for automatic control loop adjust** and **P-0-0164, Application for automatic control loop adjust** will be checked.

**4th step:** **Check speed control loop** and correct controller parameter, if need be, until correct behavior appears (depends on dynamics programmed).

**5th step:** **Check position control loop** and correct controller parameters, if need be, until aperiodic behavior in control loop appears.

**6th step: END** Wait for **new start** or **end of command**.

This drive here is idle (velocity = 0) and the display reads D9.

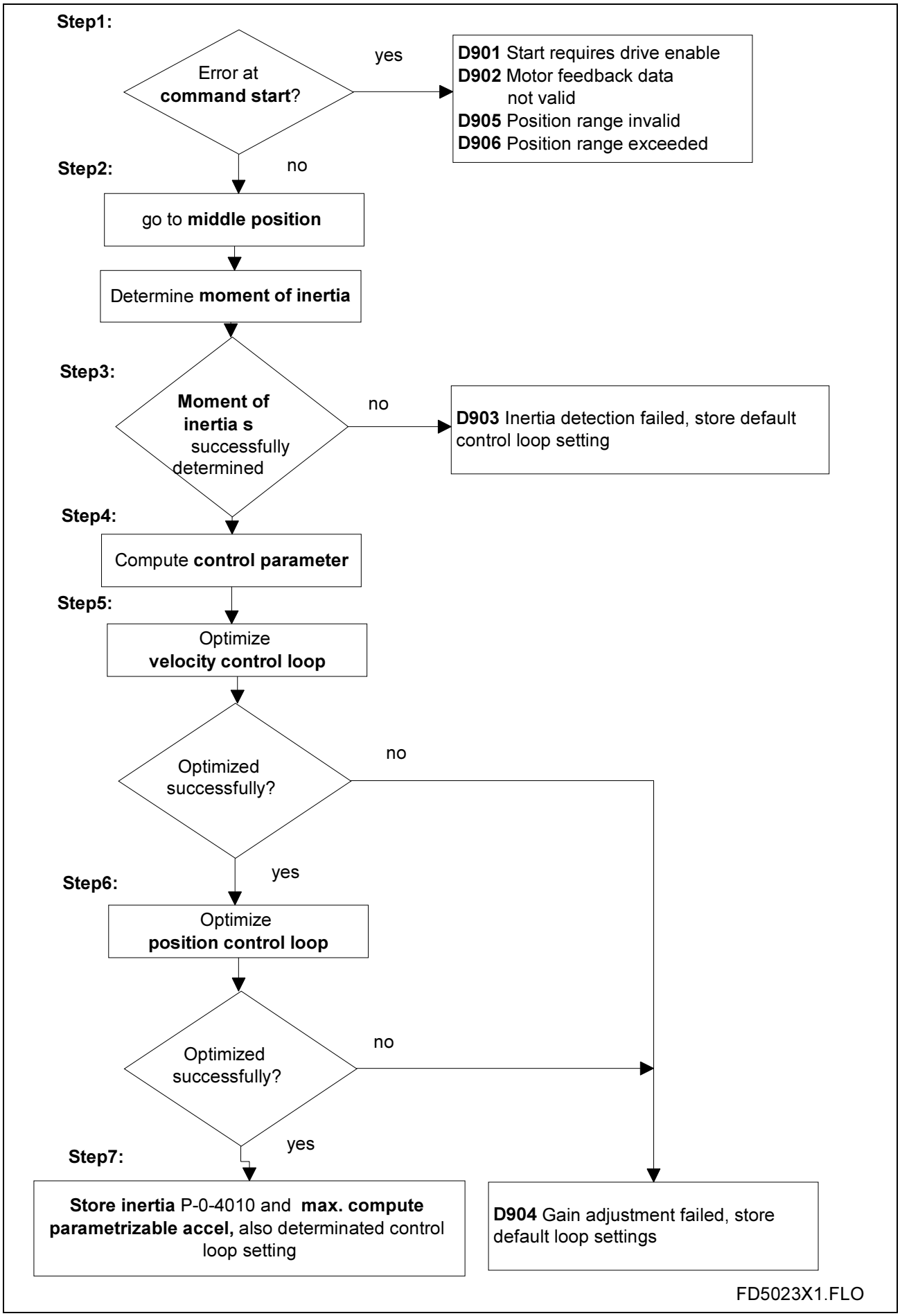



Fig. 9-78: Automatic control loop setting sequence

# Results of Automatic Control Loop Settings

**Note:** The current control loop is not effected hereby as its setting is load-dependent and set to optimum current control parameters at the factory.

The results of automatic control loop settings depends on the selection in **P-0-0165**.

**Parameter structure:**

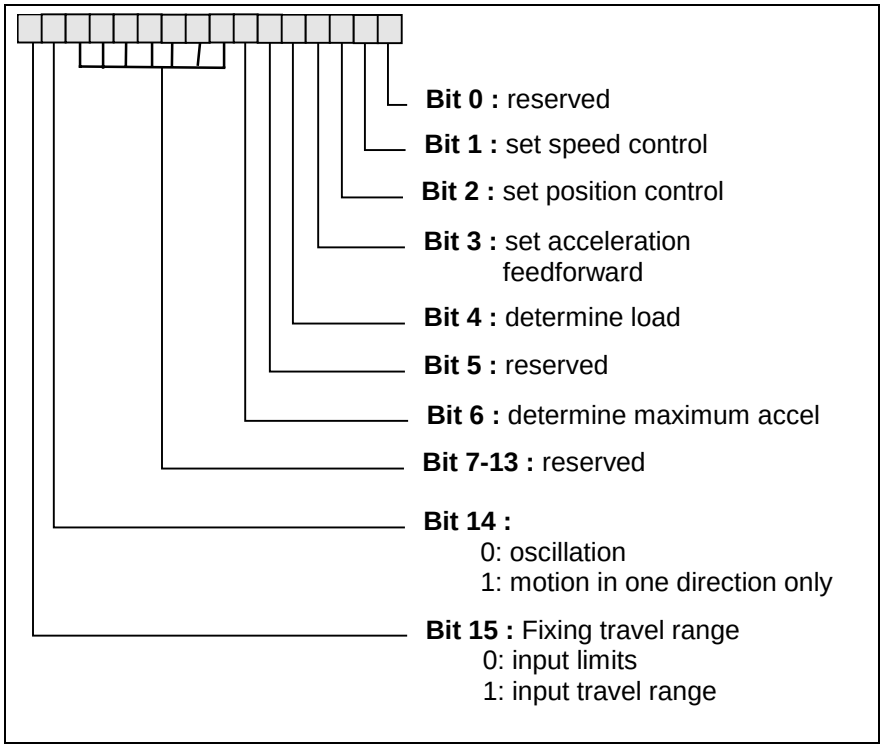

Bit 0 : reserved
Bit 1 : set speed control
Bit 2 : set position control
Bit 3 : set acceleration feedforward
Bit 4 : determine load
Bit 5 : reserved
Bit 6 : determine maximum accel
Bit 7-13 : reserved
Bit 14 :
0: oscillation
1: motion in one direction only
Bit 15 : Fixing travel range
0: input limits
1: input travel range

Fig. 9-79: Select parameter for automatic control loop settings

Possible results are:

- Set velocity control loop
- Set **position control loop**
- **P-0-4010, Load inertia** (reduced to motor shaft)
  The load determined for automatic control loop settings is stored here.
- **P-0-0168, Maximum acceleration**
  Maximum drive acceleration for loop settings is stored here.
- **S-0-0348, Acceleration feed forward gain**
  As the results of the automatic settings, the value for accel pre-control is calculated in accordance with the formula:
  **S-0-0348 = (P-0-4010 + P-0-0510) / S-0-0051**.

# 9.9 Drive Halt

The drive halt function is used to bring an axis to a standstill with a defined accel and defined jerk.

The function is activated:

- by clearing the drive halt bit
- due to setting drive halt bit to zero in fieldbus control word. The structure of the control word depends on the set profile type. For profile types I/O mode (profile type = FF80, FF81 or FF82) in bit 1, for Rexroth Indramat profile types in bit 13 of fieldbus control word.
- or by interrupting a drive control command (e.g., drive-guided referencing).

## Pertinent Parameters

Which parameters are active depends upon which operating mode was interrupted by the drive halt command

Standstill for Operating Mode "Drive Internal Interpolation":

- **S-0-0359, Positioning Deceleration** (or **S-0-0260, Positioning Acceleration**, when S-0-0359 = "0")
- **S-0-0193, Positioning Jerk**

Standstill for Operating Mode "Positioning Block Mode":

- **P-0-4063, Process block deceleration** (or **P-0-4008, Process block acceleration**, when P-0-4063 = "0")
- **P-0-4009, Process block jerk**

Standstill for Operating Mode "Jogging":

- **S-0-0260, Positioning Acceleration**
- **S-0-0193, Positioning Jerk**

Standstill for Operating Mode without drive-internal position command generation:

- **S-0-0138, Bipolar acceleration limit value**
- **S-0-0349, Jerk limit bipolar**

Standstill for Operating Mode "Velocity control" or "Torque Control":

- **P-0-1211, Deceleration ramp 1** ( or **P-0-1201, Ramp 1 pitch**, falls P-0-1211 = "0")
- **P-0-1202, Final speed of ramp 1**
- **P-0-1213, Deceleration ramp 2** ( or **P-0-1203, Ramp 2 pitch**, falls P-0-1213 = "0")

The following parameters are used for diagnostic purposes:

- **S-0-0124, Standstill window**
- **S-0-0182, Manufacturer's status class 3**

# The Functional Principle of Drive Halt

If the drive halt function is activated, then the drive does not follow the command values of the active mode but rather brings the drive to a halt while maintaining the parameterized accel.

The manner in which the standstill takes place depends on the previously activated operating mode.

**Stand still in position control with previously active decel and jerk limits values**

Standstill takes place in position control with the use of previously active decel and jerk limit values if an operating mode with drive-internal position command value generation was previously active.

Operating modes with drive-internal position command generation are:

- drive-internal interpolation
- positioning block mode
- jog mode.

If the decel parameter of the operating mode is zero, then the relevant accel parameter of the operating mode is used.

**Bringing to standstill in position control with S-0-0138 and S-0-0349**

If previously a position-control mode without drive-internal position command generation was active, then the standstill takes place in position control with the use of accel in **S-0-0138, Bipolar acceleration limit value** an the jerk in **S-0-0349, Jerk limit bipolar**.

Operating modes without drive-internal position command generation are:

- position control
- angle synchronization
- Electroni cam

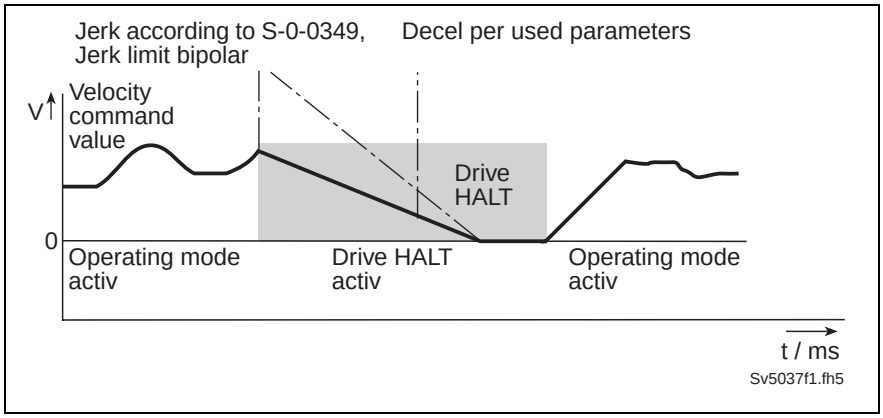



Fig. 9-80: Principle of drive halt with previously active position control without drive-internal position command value generation

**Note:** If an operating mode with position control with lag error was also previously activated, then the position controlled standstill is conducted with position control with lag error. Otherwise, the function is conducted without lag error.

**Standstill in velocity control**

If either the **velocity control** or **torque control modes** were previously active, then deceleration in velocity control uses parameters

- **P-0-1202, Final speed of ramp 1**
- **P-0-1211, Deceleration ramp 1**
- **P-0-1213, Deceleration ramp 2**

If the value of parameter **P-0-1211, Deceleration ramp 1** is zero, then parameter **P-0-1201, Ramp 1 pitch** is used.

If the value of parameter **P-0-1213, Deceleration ramp 2** is zero, then parameter **P-0-1203, Ramp 2 pitch** is used.

If parameters **P-0-1201, Ramp 1 pitch** or are equal to zero, then standstill takes place without ramp and at full torque.

---

**Note:** In all cases, the SS display reads **AH** and the diagnosis in S-0-0095 reads A010 Drive HALT.

---

**Drive halt acknowledgement**

If the actual velocity falls below the value of the parameter **S-0-0124, Standstill window**, the bit 11 "Drive Halt Confirmation" will be set in **S-0-0182, Manufacturer class 3 diagnostics**.

**Activating the operating mode**

The selected mode becomes active once again if:

- by setting the drive halt bit in the fieldbus control word. The structure of this word depends on the set profile type. For profile types I/ mode (profile type = FF80, FF81 or FF82) in bit 1, for Rexroth Indramat Profile types in bit 13 of fieldbus control word

## Connecting the drive halt input

If command communication does not use a fieldbus, e.g., SERCOS interface or Profibus, then the hardware controls the drive halt function.

For more information on this see the Project Planning Manual, sec.: Drive halt and drive enable.

# 9.10 Drive-Controlled Homing

The position feedback value of the measuring system to be referenced forms a co-ordinate system referencing the machine axis. If absolute encoders are not used, the system does not correspond to the machine co-ordinate system after the drive has been initialised.

**S-0-0148, C600 Drive controlled homing procedure command** thus supports

- the establishing agreement between drive (measuring system) and the machine co-ordinate system in non-absolute measuring systems,
- and a drive-controlled running to the reference point in absolute measuring systems.

Drive-controlled homing means that the drive independently generates the necessary motion which corresponds to the homing velocity settings and homing acceleration settings.

---

**Note:** It is possible to perform this for either the motor encoder or the optional encoder.

---

## Pertinent Parameter

To run this feature, use the following parameters:

- **S-0-0148, C600 Drive controlled homing procedure command**
- **S-0-0147, Homing parameter**
- **S-0-0298, Reference cam shift**
- **S-0-0299, Home switch offset**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0150, Reference offset 1**
- **S-0-0151, Reference offset 2**
- **S-0-0041, Homing velocity**
- **S-0-0042, Homing acceleration**
- **P-0-0153, Optimal distance home switch - reference mark**
- **S-0-0177, Absolute distance 1**
- **S-0-0178, Absolute distance 2**
- **S-0-0165, Distance coded reference offset 1**
- **S-0-0166, Distance coded reference offset 2**

The following parameters

- **S-0-0108, Feedrate override**
- **S-0-0057, Position window**
- **S-0-0349, Jerk limit bipolar**
- **S-0-0403, Position feedback value status**

also can be used.

## Setting the referencing parameters

The basic sequence is dependent on how parameter **S-0-0147, Homing parameter** has been parametrized.

The following settings are performed:

- referencing direction positive/negative
- referencing with motor or optional encoder
- evaluation of the home switch yes/no
- evaluation of the marker yes/no
- go to reference point yes/no

The parameter is structured as follows:

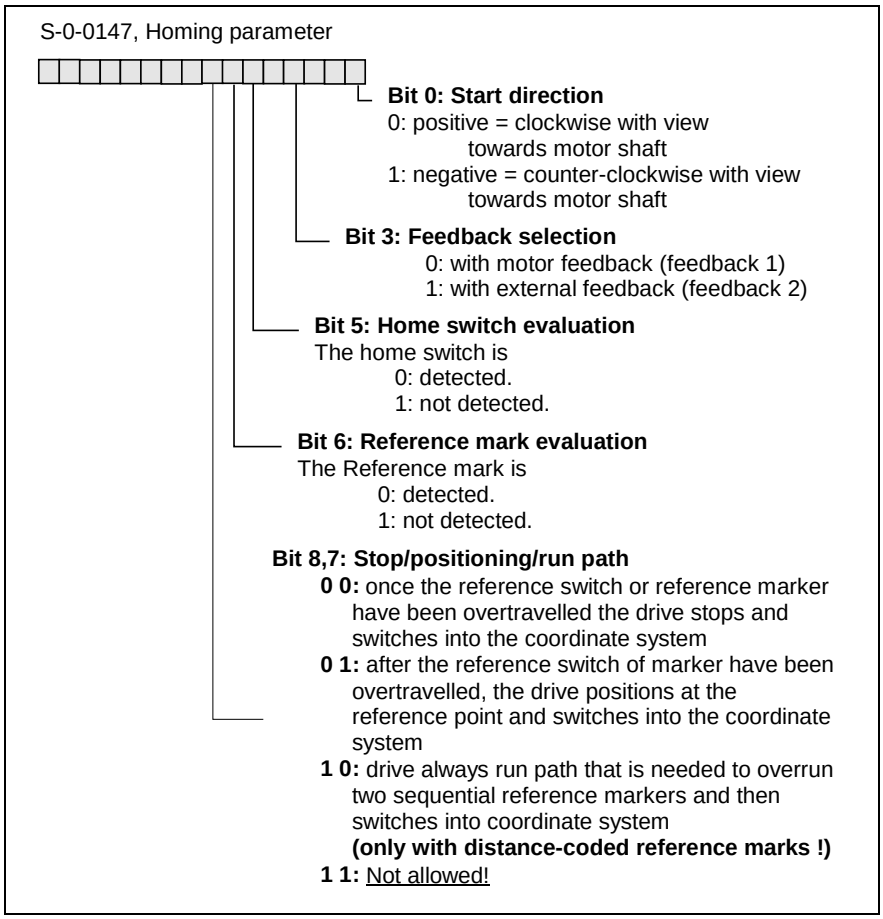

S-0-0147, Homing parameter
Bit 0: Start direction
0: positive = clockwise with view towards motor shaft
1: negative = counter-clockwise with view towards motor shaft
Bit 3: Feedback selection
0: with motor feedback (feedback 1)
1: with external feedback (feedback 2)
Bit 5: Home switch evaluation
The home switch is
0: detected.
1: not detected.
Bit 6: Reference mark evaluation
The Reference mark is
0: detected.
1: not detected.
Bit 8,7: Stop/positioning/run path
0 0: once the reference switch or reference marker have been overtravelled the drive stops and switches into the coordinate system
0 1: after the reference switch of marker have been overtravelled, the drive positions at the reference point and switches into the coordinate system
1 0: drive always run path that is needed to overrun two sequential reference markers and then switches into coordinate system
(only with distance-coded reference marks !)
1 1: Not allowed!

Fig. 9-81: Structure of parameter S-0-0147, Homing parameter

**Note:** The sequence also depends on the type and arrangement of the reference markers in terms of the referenced encoder. (see next section).

## Overview of the Type and Allocation of Reference Marks of Non-Absolute Measuring Systems

For better a understanding, you can divide the measurement systems into 4 groups according to the type and configuration of their reference marks.

- **Type 1**: Measurement systems with absolute single-turn range, such as the Single-turn DSF or Resolver. These measurement systems have an absolute range of one encoder revolution or fractions of it (resolver). Typical systems are
  - the encoders for the MHD, MKD and MKE motors
  - the GDS measurement system.
  - Single-turn encoder with ENDAT-Interface from Heidenhain
- **Type 2**: Incremental rotational measurement systems with a reference mark for each encoder rotation, such as the ROD or RON types from the Heidenhain Company.
- **Type 3**: Incremental translation measurement systems with one or several reference marks, such as the LS linear scaling of the Heidenhain Company.
- **Type 4**: Incremental measurement systems with distance coded reference marks, such as the LSxxxC linear scaling of the Heidenhain Company.

The drive-internal detection for the configuration of the reference marks is done with the settings of the corresponding position encoder type parameter **S-0-0277, Position feedback 1 type** (for motor encoder) or **S-0-0115, Position feedback 2 type** (for optional encoder).

In these parameters, you set with bit 0 whether it's a rotary or a linear measurement system, and bit 1 decides whether the measurement system has distance-coded reference markers.

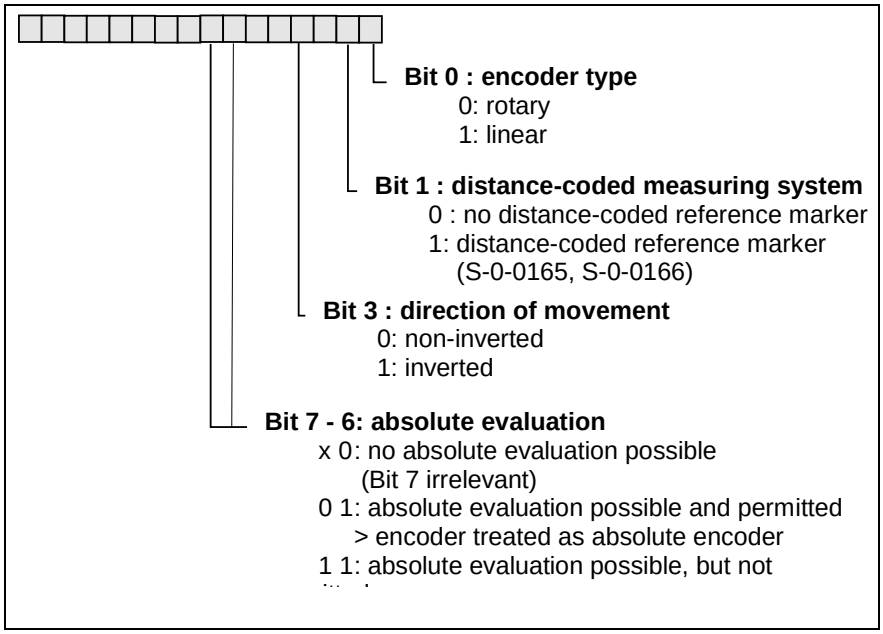

Bit 0 : encoder type
0: rotary
1: linear
Bit 1 : distance-coded measuring system
0 : no distance-coded reference marker
1: distance-coded reference marker
(S-0-0165, S-0-0166)
Bit 3 : direction of movement
0: non-inverted
1: inverted
Bit 7 - 6: absolute evaluation
x 0: no absolute evaluation possible
(Bit 7 irrelevant)
0 1: absolute evaluation possible and permitted
> encoder treated as absolute encoder
1 1: absolute evaluation possible, but not

Fig. 9-82: Structure of the position feedback type parameters S-0-0115 / S-0-0277

**Note:** For measurement systems with their own data memory (Type 1), this setting is done automatically.

See also chapter: "Setting the Measurement System".

## Functional Principle of Drive-Controlled Referencing in Non-Absolute Measuring Systems

To establish congruency between drive (measuring system) and machine co-ordinate system it is necessary that the drive has precise information about its relative position within the machine co-ordinate system. The drive receives this information by detecting the home switch edge and/or the reference mark.

**Note:** To evaluate only the home switch is not recommended as the position of the home switch edge has a lesser precision compared to the detection of the reference mark!

Co-ordinate system alignment is achieved by comparing the desired feedback position at a specific point within the machine co-ordinate system with the actual feedback position ("old" drive co-ordinate system). A differentiation in this case is made between "Evaluation of a reference mark/home switch edge" (type 1 .. 3) and "Evaluation of distance-coded reference marks".

**Definition of the reference point**

- With "Evaluation of a reference mark/home switch edge" the "specific" point within the co-ordinate system is the so-called reference point. The desired feedback position is set at this point via parameter **S-0-0052, Reference distance 1** (for motor encoders) or **S-0-0054, Reference distance 2** (for optional encoders). The physical position of the reference point derives from the position of the reference marker plus the value in **S-0-0150, Reference offset 1** or **S-0-0151, Reference offset 2**. Once the reference marker is detected, the drive knows the position of this marker and therefore also that of the reference point in the "old" drive co-ordinate system. The desired position in the new co-ordinate system referring to the machine's zero point is in parameter **S-0-0052, Reference distance 1** and **S-0-0054, Reference distance 2.**
- With "**Evaluation of distance-coded reference marks**" the "specific" point is the zero point (position of the first reference mark) of the distance-coded measuring system. By detecting the position difference between two adjacent reference marks the position of the first reference marker in the "old" drive co-ordinate system can be determined. The desired feedback position at this point is defined by the position of the first reference mark in the machine co-ordinate system at this point plus the value in **S-0-0177, Absolute distance 1** (for motor encoders) or **S-0-0178, Absolute distance 2** (for optional encoders).

In both cases, the difference between both co-ordinate systems is added to the "old" drive co-ordinate system. The co-ordinate systems will then correspond to one another.

By switching the position command and feedback value, **S-0-0403, Position feedback value status** is set to 1. This means that the feedback position value now refers to the machine zero point.

---

**Note:** If the drive, once the reference command has been conducted, is in parameter mode again, then parameter **S-0-0403, Position feedback value status** is set to 0, because the feedback values in command **S-0-0128, C200 Communication phase 4 transition check** are re-initialised.

---

See also the functional description: "Commissioning with Evaluation of reference marker/home switch edge"

See also the functional description: "Commissioning with Evaluation of distance-coded reference marker"

## Functional Principle of Drive-Guided Referencing with Absolute Measuring Systems

If the referenced measuring systems (per bit 3 of S-0-0147) is to be evaluated as an absolute measuring system, i.e., in the relevant encoder type parameter (S-0-0277/S-0-0115) bit 6 is at "1" and bit 7 on "0", then command **S-0-0148, C600 Drive controlled homing procedure command** supports two different purposes**:**

- drive-guided travelling to the reference point
- triggering the switch of the position feedback value if absolute measurement is conducted with drive enable applied.

### Drive-guided travelling to reference point

If the absolute encoder is referenced, i.e., parameter **S-0-0403, Position feedback value status** is set to "1", then the drive, after the start of command **S-0-0148, C600 Drive controlled homing procedure command** runs to the reference point if "1" is set in bit 7 of parameter **S-0-0147, Homing parameter** for "Drive on reference point after drive-guided referencing". The reference point is defined in parameters **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2**.

### Triggering position feedback value switch with absolute dimension set

If command **P-0-0012, C300 Command 'Set absolute measurement'** is conducted with drive enable applied, then the switching by the drive of the actual position value register **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** is not conducted until

- command **S-0-0148, C600 Drive controlled homing procedure command** is also conducted after the start of P-0-0012 or
- drive enable is switched off.

(See section: "Setting the Absolute Dimension".)

## Sequence control "Drive-Controlled Homing"

The command profile depends on the parameters

- **S-0-0041, Homing velocity,**
- **S-0-0108, Feedrate override**
- **S-0-0042, Homing acceleration.**

To limit the acceleration changes, you can additionally activate a jerk limit. You can do this by entering the parameter **S-0-0349, Jerk limit bipolar**.

The following diagram explains this:

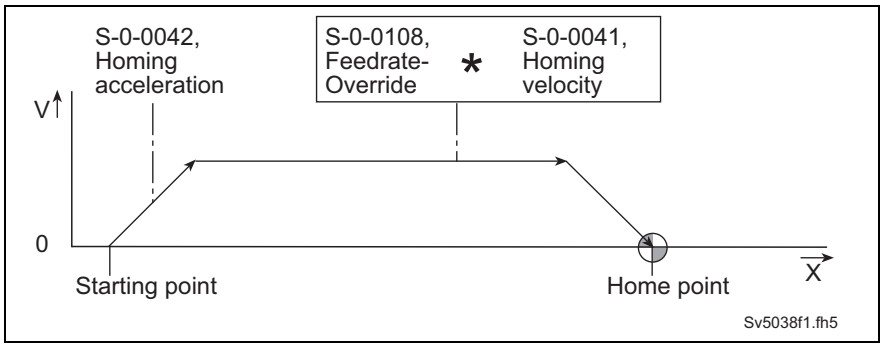



Fig. 9-83: Position command profile with homing velocity and homing acceleration

**maximum velocity**

The maximum velocity is influenced, as with all drive-controlled functions, by the feedrate. The effective maximum velocity is the result of the product of **S-0-0041, Homing velocity** and **S-0-0108, Feedrate override**.

**Note:** If the parameter **S-0-0108, Feedrate-Override** is set with zero, then warning **E255 Feedrate-Override S-0-0108 = 0** will be generated.

**motional process**

The motional process during drive-controlled homing of non-absolute encoders can be made up of up to three processes:

- If the home switch evaluation process has been activated and there are no distance-coded reference markers, then the drive accelerates to the homing velocity in the selected homing direction until the positive home switch edge is detected. If the drive is already on the home switch at the start of drive-controlled referencing (**S-0-0400, Home switch** = 1), the drive at first accelerates in the opposite direction until the negative home switch edge is detected, and then reverses the direction.

**WARNING**

⇒ Make sure that the home switch trigger edge lies within the reachable travel range.

- If reference markers are available (type 2 to 4, see above), and if the reference marker evaluation is activated, then the drive runs in homing direction until it detects a reference marker. In distance-coded measuring systems (type 4), two sequential reference markers must be passed. The reference markers are always evaluated there (independent of bit 6 in S-0-0147).

**S-0-0147, Bit 7 = 0**

- The further action depends on how bit 7 has been set in **S-0-0147, Homing parameter**. If bit 7 = 0 is programmed ("any position after homing"), then the drive brakes with the programmed homing acceleration up to standstill. If the value of the velocity feedback is less than the value set in **S-0-0124, Standstill window**, then the co-ordinate system of the referenced encoder is set, and the command is signalled as completed.

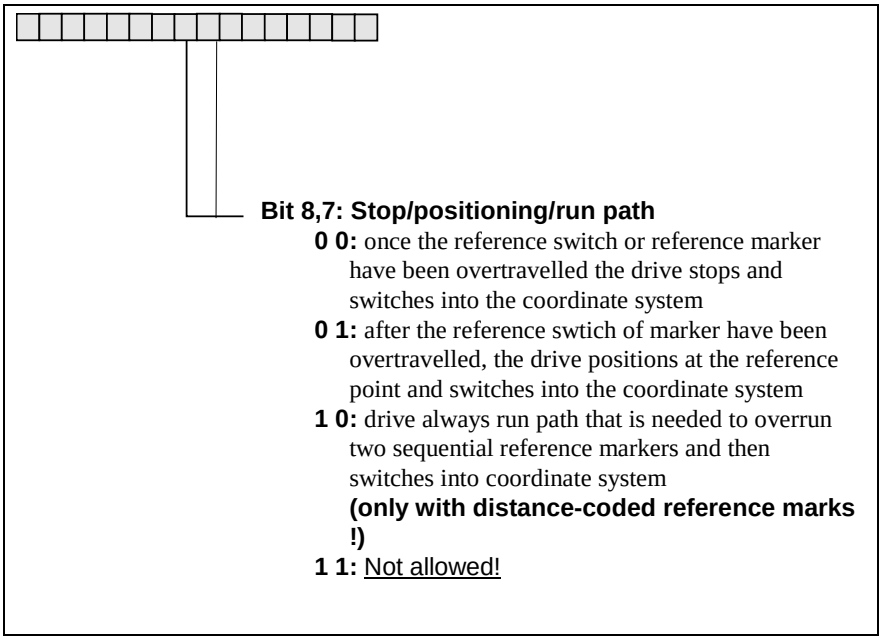

Bit 8,7: Stop/positioning/run path
0 0: once the reference switch or reference marker have been overtravelled the drive stops and switches into the coordinate system
0 1: after the reference swtich of marker have been overtravelled, the drive positions at the reference point and switches into the coordinate system
1 0: drive always run path that is needed to overrun two sequential reference markers and then switches into coordinate system
(only with distance-coded reference marks !)
1 1: Not allowed!

Fig. 9-84: Bit 7 and 8 of **S-0-0147, Homing parameter**

**Motion profile prior to coordinate system switching**

The further course depends on what was set in bits 7 and 8 **S-0-0147, Homing Parameter**. There are three options.

- Stopping: After the necessary motions to detect the reference switch or marker have been executed, the drive stops with the programmed homing acceleration. Once a speed is reached that is less than the value set in **S-0-0124, Standstill window,** then the switch to the co-ordinate system (position feedback value switching) is performed and the successful completion of the command is signalled.
- Positioning: After the necessary movements to detect the reference switch or marker have been completed, the drive positions at the reference point. This point for non-distance-coded measuring systems is the sum of the position of the relevant reference mark/switch trigger edge plus the reference dimension offset. The reference point for distance-coded encoders is the position of the 2nd over-travelled reference marker.
- Running paths: During the homing procedure, the drive runs a specific path. This mode is only possible with distance-coded measuring systems. The path is fixed by what has been set in parameter **S-0-0165, distance-coded reference 1**. By following off the path that has been programmed here, it is assured that the drive will always overrun two sequential markers. This function makes sense, for example, in gantry axes (parallel, mechanically coupled axes) equipped with distance-coded measuring systems. By activating this mode in all of the coupled axes it is ensured that at the simultaneous start of command **S-0-0148, C600 Drive-guided reference** every drive will run the same profile.

**Note:** If the "Run path" mode is used with gantry axes, then the gantry axes are not automatically run in parallel by the referencing procedure. The mechanically coupled axes only run a relative path. Their shared position reference does not change. (In contrast to the "Positioning" mode that is only possible with non-distance-coded encoders, where the axes are automatically run in parallel by the driveside referencing procedure itself.)

## Actual Feedback Values After the "Drive-Controlled Homing" Command

The position feedback values from the motor and optional encoders, after the "**drive-controlled homing"** command is processed, depend on bit 3 in **S-0-0147, Homing parameter** and on the availability of an absolute encoder as a motor or optional encoder.

| Motor encoder: | Ext. encoder: | S-0-0147 Bit 3: | Actual feedback value 1: | Actual feedback value 2: |
|---|---|---|---|---|
| absolute | Not absolute | 1 | unchanged | reference distance 2 |
| not absolute | absolute | 0 | reference distance 1 | unchanged |
| not absolute | not absolute | 0 | reference distance 1 | reference distance 1 |
| not absolute | not absolute | 1 | reference distance 2 | reference distance 2 |

Fig. 9-85: Position feedback values after the drive-controlled homing command

# Commissioning with "Evaluation of reference marker/home switch edge"

If the encoder does not have distance-coded reference marks (type 1 to 3), then select in **S-0-0147, Homing parameter** whether

- home switch evaluation is desired or not and/or
- reference mark evaluation is desired.

Additionally it must be defined,

- in which direction the drive should move with the start of the command **"Drive-controlled homing"** as well as whether
- the drive should go to the reference point or not.

If a home switch evaluation becomes necessary, then the necessary settings must first be made (see "Evaluation of the Home Switch"). All additional steps can then be conducted as follows:

⇒ Check the relevant position encoder type parameter (S-0-0277 / S-0-0115) to make sure it has been correctly set.

⇒ Parametrize the following parameter with 0

- **S-0-0052, Reference distance 1 or**
- **S-0-0054, Reference distance 2**
- **S-0-0150, Reference offset 1 or**
- **S-0-0151, Reference offset 2.**

⇒ Set parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** to small values (e.g., S-0-0041 = 10 Rpm, S-0-0042 = 10 rad/s².

⇒ Conduct the drive-controlled homing command.

---

**Note:** If the command is cleared, then the original operating mode becomes active. If drive-internal interpolation is set, then the drive immediately runs to the value set in S-0-0258, Target position. This value relates to the new (machine zero point) co-ordinate system!

---

**Result of the Drive-Controlled Homing-Command**

The command should be completed without error. The machine zero point is at the position of the home switch or the referencing point as the reference distances (S-0-0052/54) have been parametrized with 0. The position feedback value in **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** should now have absolute reference to this preliminary machine zero point.

To set the correct machine zero point, you can now conduct the following steps:

⇒ Run the axis to the desired machine zero point and enter the feedback position value displayed there with opposite sign in **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2.**

or:

⇒ Run the axis to position feedback value = 0, measure the distance between the current position and the desired machine zero point. Enter the distance in **S-0-0052, Reference distance 1** or **S-0-0054, Reference distance 2.**

Once the drive-controlled reference command is again completed, the position feedback value should refer to the desired machine zero point.

The reference point can be shifted relatively to the reference mark (see "Consideration of the reference offset").

Parameter **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** can now be set to their final values.

## Consideration of the Reference Offset

If the evaluation of the reference mark is activated in the homing parameter, then the reference point is always set on the position of the selected reference mark. If a measurement system of type 1..3 is present (not distance-coded), you can shift the position of the reference point relatively to the reference marker. Doing so, you can select any position after homing.

The offset is set with the parameters

- **Reference Offset 1** (for motor encoder)
- **Reference Offset 2** (for optional encoder)

**positiv reference offset**

If the **reference offset is positive**, then its drive-internal direction is positive (see "Command Polarities and Actual Value Polarities"). In other words, the reference point is moved in terms of the reference mark in a clockwise direction when looking towards the motor shaft. If the homing direction is also positive, then the drive does not reverse the direction after passing the reference marker.

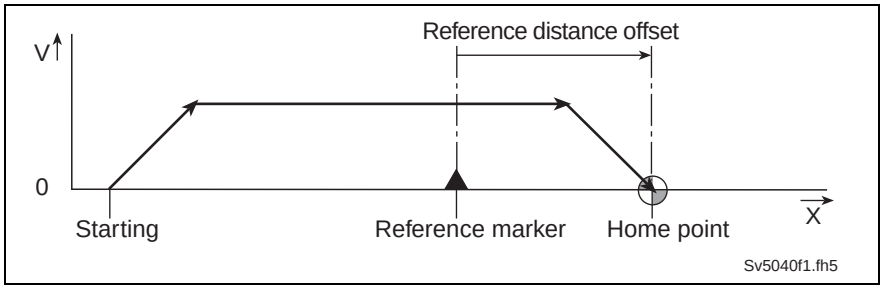



Fig. 9-86: Command value profile for positive reference offset and positive homing direction

If the **reference direction is negative**, then the drive must reverse the direction (with types 2 and 3) after passing the reference marker.

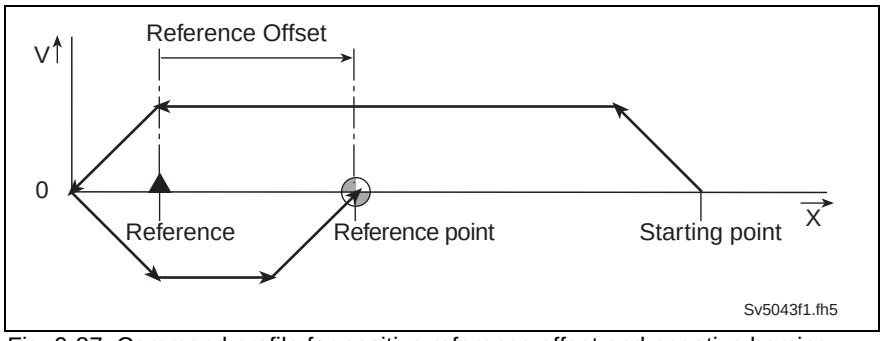



Fig. 9-87: Command profile for positive reference offset and negative homing direction

**Negative reference offset**

If the **reference offset is negative**, then its drive-internal direction is negative (see chapter: "Command Polarities and Actual Value Polarities"). In other words, the reference point is shifted counterclockwise looking towards the motor shaft. If the reference direction is negative, then the drive does not reverse the travel direction once it has passed the reference marker.

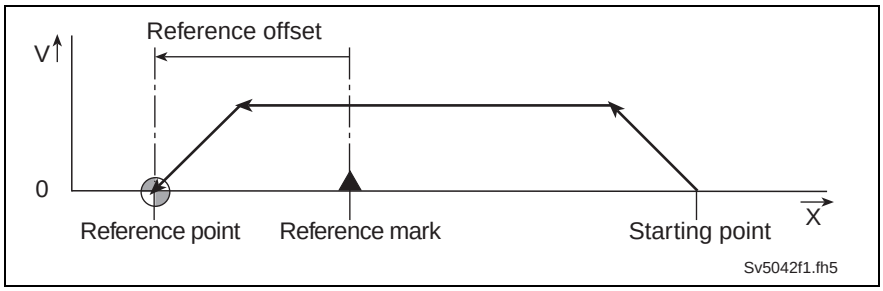



Fig. 9-88: Command profile with negative reference offset and negative homing direction

If the referencing direction is positive, then the drive must reverse the travel direction (with types 2 and 3) after passing the reference marker.

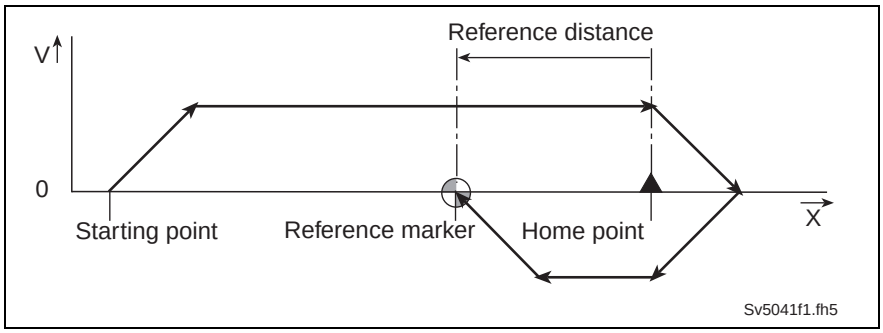



Fig. 9-89: Command profile with negative reference offset and positive homing direction

## Evaluation of the Home Switch

**Home switch evaluation**

With the help of a home switch it is possible to identify a certain reference mark in the case where an unspecific arrangement of reference marks are used. If bit 5 in S-0-0147 = 0, then the reference mark, that follows the positive edge of the home switch will be evaluated (if the drive is moving towards the homing point).

---

**Note:** The home switch input is pictured in parameter **S-0-0400, Home switch**

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**Example:** Homing of a motor encoder with 1 reference mark per revolution

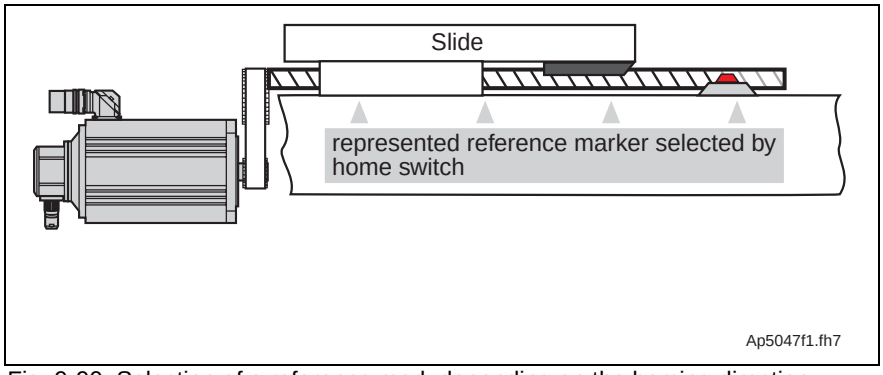



Fig. 9-90: Selection of a reference mark depending on the homing direction

If **home switch evaluation is activated**, the drive searches at first for the positive edge of the home switch. If the home switch is not actuated at the beginning of the command, the drive moves in the preset homing direction.

**Note:** The homing direction must be set so that the positive edge can be found.

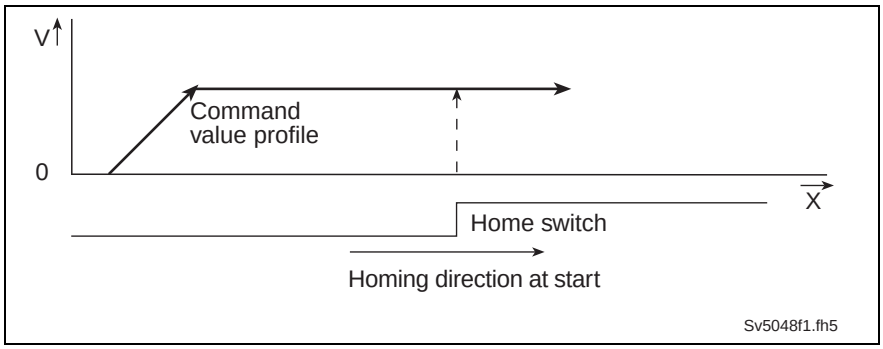



Fig. 9-91: Correct setting of homing direction

**WARNING** If the homing direction setting is incorrect, the drive command value moves away from the positive home switch edge. In this case the danger exists that the drive reaches the travel range limits. This may result in damage to the system!

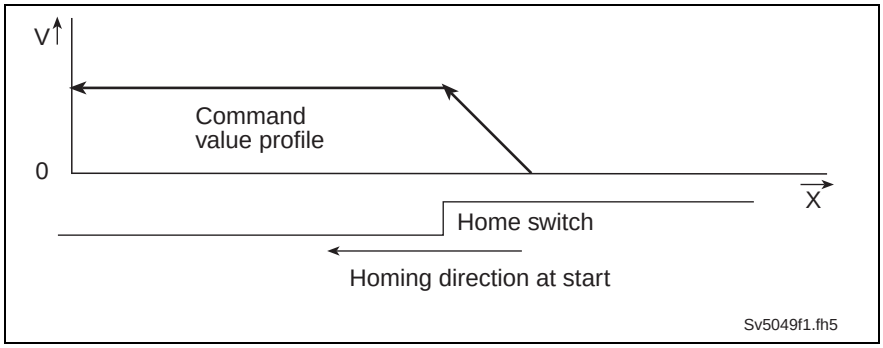



Fig. 9-92: Incorrectly set homing direction

## Command value profile with actuated home switch at the start of the command

If the home switch is actuated already when the command is started, the drive generates command values in the opposite direction to move away from the home switch. As soon as a 1-0 edge from the home switch is detected, the drive reverses its direction and continues as if started outside the home switch range.

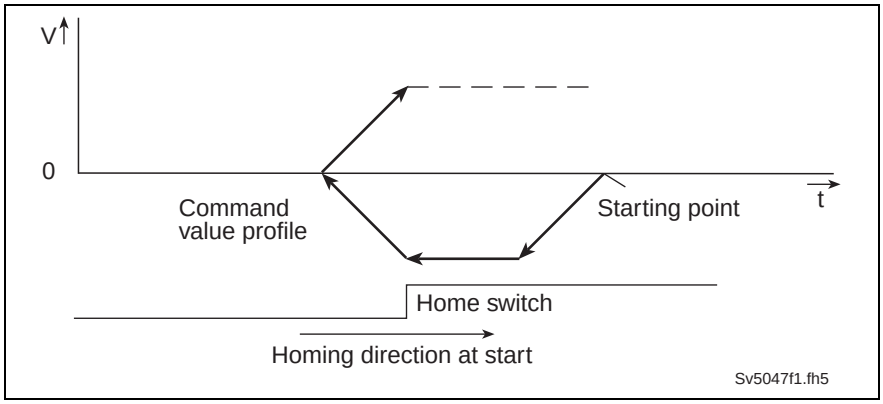



Fig. 9-93: Command profile with start position on the home switch

## Monitoring the Distance Between Home switch and Homing Mark

If the distance becomes too small between the home switch edge and the reference mark, then it is possible that the home switch edge will only be detected after the reference mark has already passed. This leads to the detection of the following reference mark, and the reference mark detection becomes ambiguous.

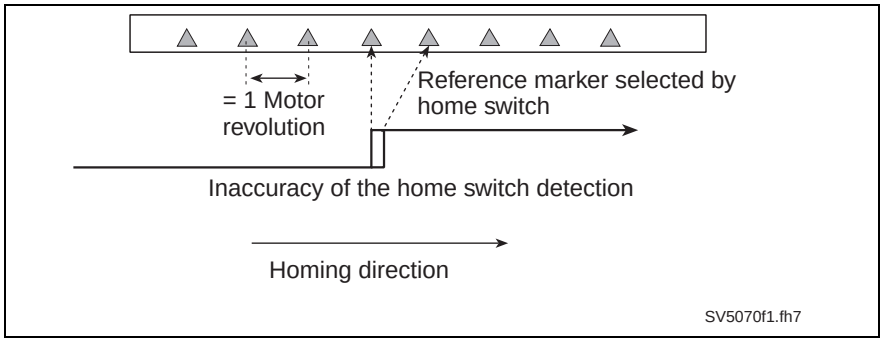



Fig. 9-94: Ambiguous detection of reference markers at small distances between home switch edge and reference mark

The distance between the home switch edge and the reference mark is monitored for this reason.

If the distance between the home switch edge and the reference mark becomes smaller than a certain value, the command error **C602 Distance home switch - reference mark erroneous** will be generated.

The Critical Range for the distance is:

0.25 • Distance between reference markers

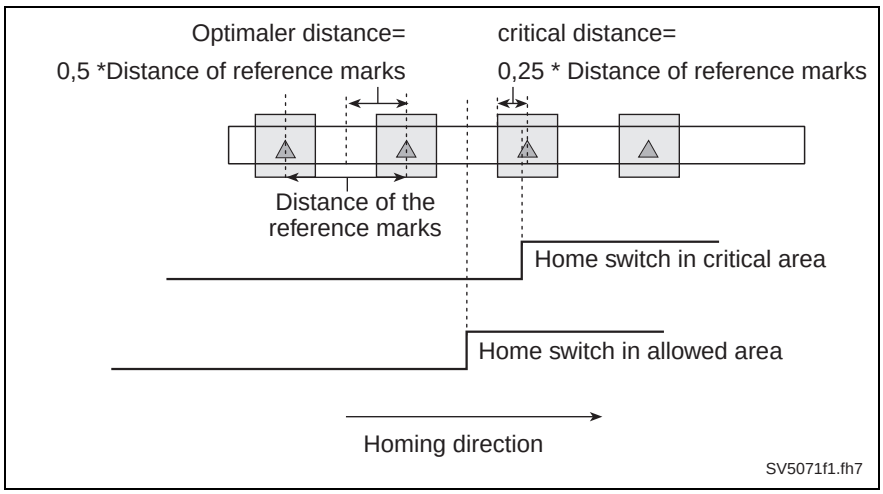



Fig. 9-95: Critical and optimal distance between home switch and reference mark

The optimum distance between the home switch edge and the reference marker is:

0.5 • Distance between reference markers

To monitor the distance between the home switch and the reference mark, the optimal distance is entered in **P-0-0153, Optimal distance home switch - reference mark**.

The following requirements apply:

| Encoder type | P-0-0153 | Function |
|---|---|---|
| Rotary | 0 | The distance between the home switch and the reference mark will be monitored. The optimal spacing will be calculated internally and amounts to a 1/2 encoder rotation for DSF or incrementally rotational encoders, or 1/2 encoder revolution / **S-0-0116, Feedback 1 Resolution** for resolvers. |
| Rotary | x | The distance between the home switch and the reference mark will be monitored. Half the reference mark spacing must be entered in **P-0-0153, Optimal distance home switch - reference mark**. |
| Linear | 0 | The distance between the home switch and the reference mark will not be monitored. The linear scale does not affect reference marks with consistent intervals. The real distance between the home switch and the reference mark must be big enough to achieve a sure recognition of the home switch edge when considering the maximum homing velocity and the cycle time for the home switch input polling. |
| Linear | x | The distance between the home switch and the reference mark will be monitored. Half the reference mark spacing must be entered in **P-0-0153, Optimal distance home switch - reference mark**. |

Fig. 9-96: Monitoring the distance Home switch-Reference Mark

For every homing with home switch evaluation, the difference between actual distance and optimal distance is monitored. The difference is saved in parameter **S-0-0298, Reference cam shift**. The home switch edge can be shifted mechanically for this value.

To avoid a mechanical shifting of the home switch edge, you can set this procedure in the software with the parameter **S-0-0299, Home switch offset**. The value in parameter **S-0-0298, Reference cam shift** is transferred to parameter **S-0-0299, Home switch offset**.

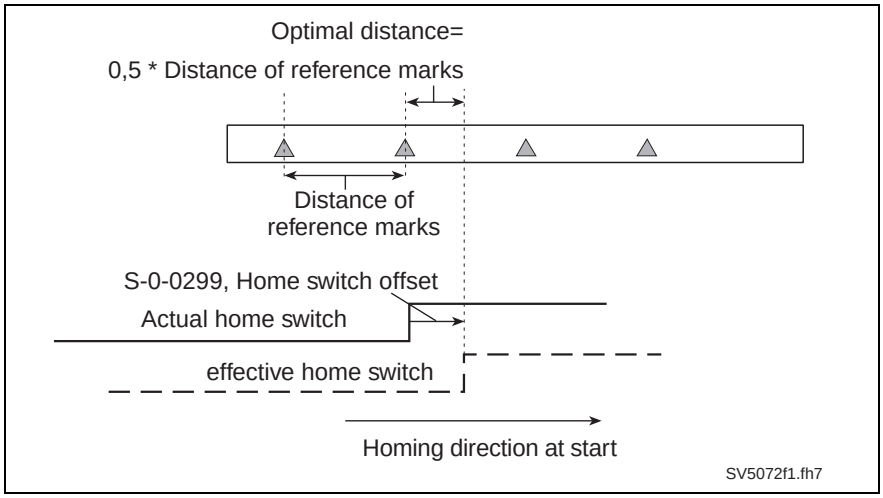



Fig. 9-97: Operation of parameter S-0-0299, Home Switch Offset

The parameter **S-0-0299, Home switch offset** can be set as follows:

- Running the homing command with **S-0-0299, Home switch offset** = 0.
- If the distance is not in the range between 0.5..1.5 * **P-0-0153, Optimal distance home switch - reference mark,** the error message **C602 Distance home switch - reference mark erroneous** will be generated. In this case, you have to enter the value **S-0-0298, Reference cam shift** into **S-0-0299, Home switch offset**.
- Check: You should see a 0 displayed in **S-0-0298, Reference cam shift** when homing is restarted.

# Commissioning with "Evaluation of distance-coded reference marker"

If the encoder has distance-coded reference markers (type 4), then it must be set in **S-0-0147, Homing parameter**

- whether the home switch should be evaluated and/or
- in which direction the drive should move at the start of the command "Drive-controlled homing",
- and whether the drive should position at the position of the 2nd overrun reference mark, whether it should stop after the 2nd reference mark is overrun, or whether a specific path is to be run (especially in the case of gantry axes).

## Determining the travel path in "Run path" mode

If in bits 7 and 8 of **S-0-0147, Homing parameter** the "Run path" mode has been programmed (see function sequence of "Drive-controlled referencing"), then the drive always runs a path defined by parameter **S-0-0165, Distance coded reference offset 1**.

**homing of a translatory motor encoder (encoder 1)**

For the homing of a translatory motor encoder (encoder 1) it applies:

$$S_{Refen} = S\text{-}0\text{-}0165 \bullet S\text{-}0\text{-}0116$$

S-0-0165: Value in Parameter S-0-0165, Distance coded reference offset 1
S-0-0116: Feedback 1 Resolution
$S_{Refen}$: Travel path

Fig. 9-98: Travel path when referencing with distance-coded reference marks and in "Run path" mode for translatory measuring systems (linear scales)

**homing of a translatory optional encoder (encoder 2)**

For the homing of a translatory optional encoder (encoder 2) it applies:

$$S_{Refen} = S\text{-}0\text{-}0165 \bullet S\text{-}0\text{-}0117$$

S-0-0165: Value in Parameter S-0-0165, Distance coded reference offset 1
S-0-0117: Feedback 2 Resolution
$S_{Refen}$: Travel path

Fig. 9-99: Travel path when referencing with distance-coded reference marks and in "Run path" mode for translatory measuring systems (linear scales)

**homing of a rotary motor encoder (encoder 1)**

For the homing of a rotary motor encoder (encoder 1) it applies:

$$S_{Refen} = \frac{360Deg \bullet S-0-0165}{S-0-0116}$$

S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0116: Feedback 1 Resolution
$S_{Refen}$ Travel path

Fig. 9-100: Travel path when referencing with distance-coded reference marks and in "Run path" mode for rotary measuring systems

**homing of a rotary optional encoder (encoder 2)**

For the homing of a rotary optional encoder (encoder 2) it applies:

$$S_{Refen} = \frac{360Deg \bullet S-0-0165}{S-0-0117}$$

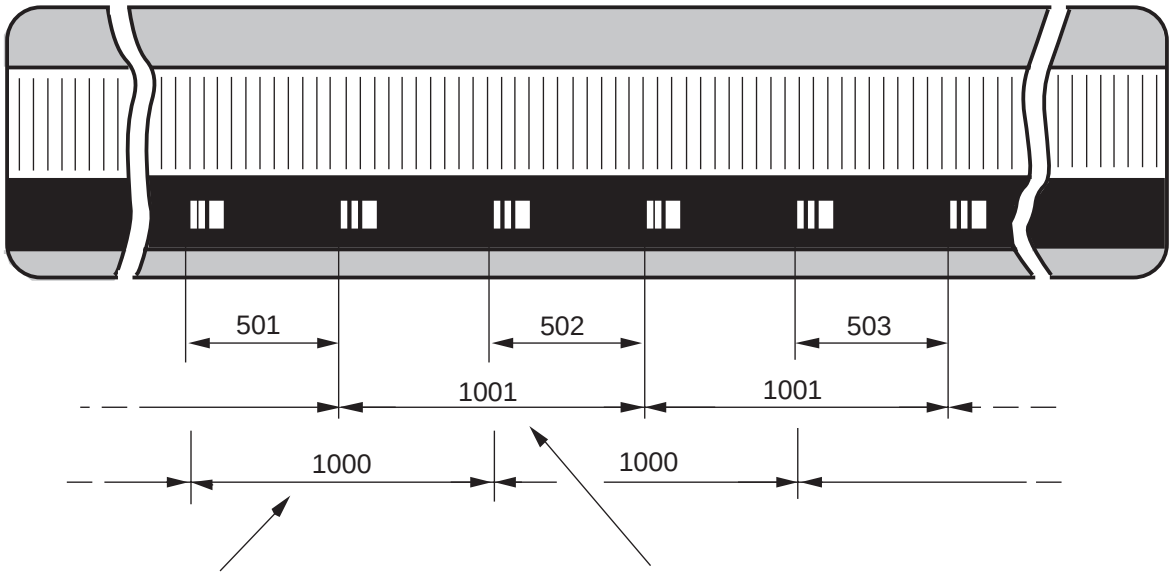
S-0-0165: Value in parameter S-0-0165, Distance coded reference offset 1
S-0-0117: Feedback 2 Resolution
$S_{Refen}$ Travel path

Abb. 9-101: Travel path when referencing with distance-coded reference marks and in "Run path" mode for rotary measuring systems

In parameters

- **S-0-0165, Distance coded reference offset 1** and
- **S-0-0166, Distance coded reference offset 2**

the greater and smaller distance of the reference mark must be entered. These values can be retrieved from the encoder specification.




„Distance-coded reference dimension 2“ (smaller value) SERCOS-ID No.:S-0-0166; Input unit: pitch

The manufacturer of the length measuring system indicates:
distance travelled up to the absolute position value: 20 mm
pitch unit: 20 µm (0-02 mm)

20 mm: 0.02 mm = 1000 pitch units

This value (1000 pitch units) is to be entered in parameter ID No. S-0-0166.

„Distance-coded reference dimension 1“ (larger value) SERCOS ID No. S-0-0165.
Input unit: pitch unit

For Heidenhein length measuring system the larger value is the product of:
(distance travelled + pitch unit):
pitch unit, therefore:
20.02 mm: 0.02 mm = 1001 pitch units

This value (1001 pitch units) is to be entered in parameter ID No. S-0-0165.

Setting up of distance-coded Heidenhain length measuring systems
(taken from: Catalog for NC length measuring systems, September 1993):

| Length measuring system Type | Distance travelled: in mm | Pitch unit: in µm | Input in: ID No.: S-0-0166 | Input in: ID No.: S-0-0165 |
|---|---|---|---|---|
| LS 403C<br>LS 406C<br>LS 323C<br>LS 623C<br>LS 106C<br>ULS 300C | 20 | 20 | 1000 | 1001 |
| LS 103C<br>LS 405C<br>ULS 300C | 10 | 10 | 1000 | 1001 |
| LID 311C<br>LID351C | 20 | 10 | 2000 | 2001 |

Pi5005f1.fh5

Fig. 9-102: Distance-coded measuring system specified with greater and smaller distance

The greater distance is entered in **S-0-0165, Distance coded reference offset 1**, in **S-0-0166, Distance coded reference offset 2** the smaller distance. The unit of these two parameters is (division) periods. Typical values for a linear scale with distance-coded reference marks are 20.02 mm for the greater distance and 20.00 mm for the smaller distances with a resolution of 0.02mm. In parameter S-0-0165/166 enter the value 1001 or 1000.

The further steps are outlined below.

⇒Check the relevant position encoder type parameter (S-0-0277/S-0-0115) to the correct setting.

⇒The parameters **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2** must be parametrized with 0.

⇒The parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** must be set to smaller values (e.g., S-0-0041 = 10 rpm, S-0-0042 = 10 rad/s².

⇒Execute command drive-controlled reference

**WARNING**

⇒ **If the command is cleared, then the original operating mode becomes active again. If drive-internal interpolation is set, then the drive immediately goes to the value set in** S-0-0258, **Target position**. **This value relates to the new (machine zero point related) co-ordinate system!**

**Result ot the Drive-Controlled-Home Command**

The command should be completed without error. The machine zero point is at the position of the first reference mark of the distance-coded measuring system as the absolute offset (S-0-0177/0178) was parametrized with 0. The relevant position feedback value in **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** should now have the absolute reference to this preliminary machine zero point. To set the correct machine zero point, the following steps can be conducted:

⇒ Move the axis to the desired machine zero point and enter the position feedback value displayed there with the opposite sign in **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2.**

Or:

⇒ Run the axis to position feedback value = 0 and measure the distance between the current position and the desired machine zero point. Enter the distance in **S-0-0177, Absolute distance 1** or **S-0-0178, Absolute distance 2.**

Once the drive-controlled reference command is again completed, the position feedback value should refer to the desired machine zero point.

Parameters **S-0-0041, Homing velocity** and **S-0-0042, Homing acceleration** can now be set to their final values.

## Home switch Evaluation with Distance coded Reference Markers

To evaluate a home switch together with homing of a distance coded measuring system serves only one purpose: staying within the allowed travel range.

**Higher security with a home switch**

If the home switch is not evaluated, the drive always covers the distance in the selected homing direction which is necessary to capture 2 adjacent marker positions. This distance is

$$s_{\mathrm{Re}\,f\,\max} = (\mathrm{S\text{-}0\text{-}0165} * \text{ Feedback Resolution}) + \frac{v^2}{2 \times a}$$

S-0-0165: Distance coded reference offset 1 S-0-0165, Distance coded reference offset 1
v : value in S-0-0041, Homing velocity
a : value in S-0-0042, Homing acceleration
$s_{\mathrm{Re}\,f\,\max}$ : maximum travel distance for homing with distance coded reference markers
S-0-0116: Feedback 1 Resolution
S-0-0117: Feedback 2 Resolution

Fig. 9-103: Travel distance for homing with distance coded reference markers

If the drive is closer to the travel limit in homing direction than the necessary travel distance $S_{Refmax}$, it can leave the allowed travel range and do mechanical damage to the machine. To avoid this,

- make sure that the distance of the axis to the travel limit at start of the command **S-0-0148, C600 Drive controlled homing procedure command** is greater than the max. necessary travel distance $S_{Refmax}$, or
- evaluate the home switch.

**Home switch evaluation**

If the home switch is evaluated, and if at the command start the home switch is already activated (**S-0-0400, Home switch** = 1), the drive automatically starts in the opposite homing direction.

Therefore, the home switch must be mounted in such a way that it covers at least the max. necessary travel distance $S_{Refmax}$ until reaching the travel range limit in the homing direction.

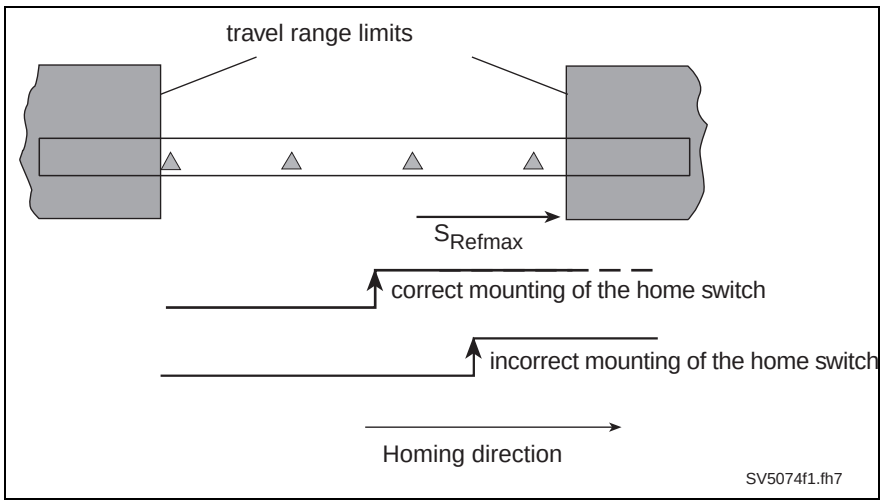



Fig. 9-104: Mounting the home switch with distance coded reference markers

## Functions of the Control During "Drive-Controlled Homing"

*The control's interpolator must be set to the position command value read from the drive.*

During "drive-controlled homing", the drive independently generates its position command values. Preset command values of the control will be ignored. If the command is confirmed by the drive as completed, the position command value corresponding to the machine zero point will be made available in parameter **S-0-0047, Position command value**. This value must be read through the service channel by the control before ending the command, and the control interpolator must be set to this value. If this command is completed by the control and if the command values of the control for the drive become active again, these values should be added to the value read out of the drive.

### Starting, interrupting and completing the command "Drive-Controlled Homing"

This feature is implemented as a command.

To start the feature, you must set and execute the command" by writing to the parameter **S-0-0148, C600 Drive controlled homing procedure command** ( Input = 3 = 11bin ). The drive confirmation has to be received from the data status out of the same parameter. The command is finished when the command-change bit in the drive status word is set and the confirmation changes from *in process* ( 7 ) to *command executed* ( 3 ) or to *command error* ( 0xF ).

If the command is interrupted (Input = 1) during processing ( when confirmation = 7 ), the drive responds by activating the drive halt feature. The program continues if the interruption is cancelled.

(See also chapter: "Drive Halt".)

## Possible Error Messages During "Drive-Controlled Homing"

During the execution of the command, the following command errors can occur:

- Drive Stop**C601 Homing only possible with drive enable**
  While starting the command, the controller enable was not set.
- **C602 Distance home switch - reference mark erroneous**
  The distance between home switch and reference mark is too small, see
- Monitoring the Distance Between Home switch and Homing Mark on page 9-97
- **C604 Homing of absolute encoder not possible**
  The homing encoder is an absolute encoder. The command "Drive-Controlled Homing" was started without first starting the command "Setting the Absolute Dimension".

- **C606 Reference mark not detected**
  For incremental encoders, the recognition of the reference mark captures the actual position. While searching the reference mark during homing, the performed distance is monitored. If the performed distance is greater than the calculated max. distance necessary to detect a reference mark, the error message C606 Reference not detected is generated. The monitoring is done with the following encoder types:
  - Rotary incremental encoder: Maximum travel path equals one encoder revolution if “0” has been set in **P-0-0153, Optimal distance home switch - reference mark**. If P-0-0153 has not been parametrized with "0", then the maximum travel path equals twice the value of P-0-0153.
  - Linear incremental encoder: maixmum travel path equals twice the value of P-0-0153, if P-0-0153 = "0" then there is no monitoring!
  - Distance-coded measuring systems: maximum travel path defined with **S-0-0165, Distance coded reference offset 1**.

The cause for this error message can be:

- No recognition of the reference marks possible (because of wire break, defective encoder, etc.).
- **S-0-0165, Distance coded reference offset 1** has a wrong value.

## Configuration of the Home switch

**Note:** The home switch should be set up, so that the activation range remains within the travel range of the axis. Otherwise, the travel range may be overrun at command start if the start position is in an unfavourable position. Damage to the system is possible !

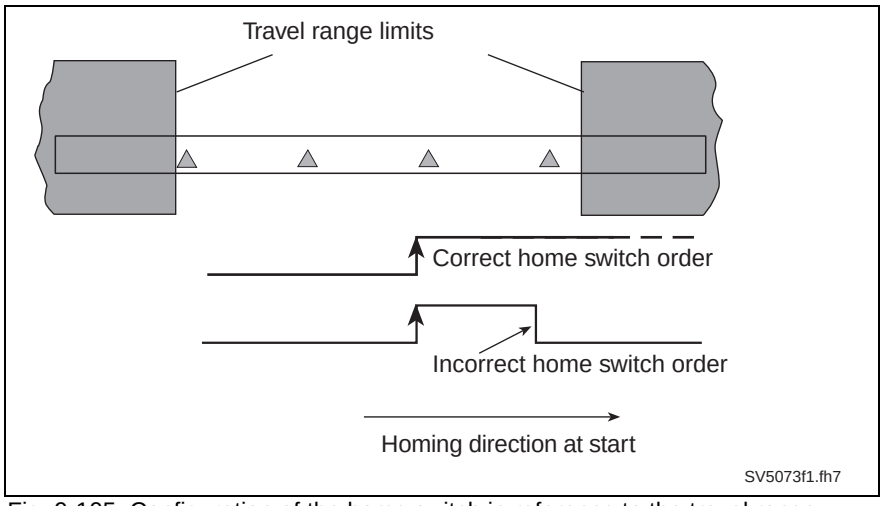



Fig. 9-105: Configuration of the home switch in reference to the travel range

## Connection of the Home switch

see project planning manual.

# 9.11 Setting the Absolute Dimension

When commissioning an absolute measuring system, the initial actual position value represents just any point on the machine and not the machine zero point.

**Note:** The value of **S-0-0403, Position feedback value status** is "0".

**Establishing the absolute reference**

In contrast to non-absolute measuring systems, finding the absolute dimension of an absolute measuring system is something that only has to be done once, namely at the time that the axis is commissioned.

With the use of command **C300 Set absolute measuring** the actual position value of this measuring system can be set to the desired value. After "Setting the absolute dimension" procedure has been completed, then the actual position value of the relevant encoder has a defined reference point for its machine zero point.

**Activating the function**

The command can be triggered by:

- writing into parameter **P-0-0012, C300 Command 'Set absolute measurement'**
- or with a zero switch input flank.

**Command reference point**

If there is only one absolute measuring system, then the command automatically references this one system. Given two absolute systems, however, then the selection must be set in **Bit 3** of **S-0-0147, Homing parameter**.

**Saving the data**

All information is retained by buffering all the data of the system in a feedback memory or a parameter memory. The actual position value retains its reference to the machine zero point each and every time the machine is switched on after being switched off.

## Pertinent Parameters

The following parameters are relevant to the execution of commands:

- **P-0-0012, C300 Command 'Set absolute measurement'**
- **P-0-0612, Control word for setting absolute measurement**
- **S-0-0147, Homing parameter**
- **S-0-0052, Reference distance 1**
- **S-0-0054, Reference distance 2**
- **S-0-0403, Position feedback value status**
- **S-7-0177, Absolute distance 1**
- **S-7-0178, Absolute distance 2**

## Functional Principle

The motor is brought to a precise position. The value of the actual position of the measuring system is entered in parameters **S-0-0052, Reference distance 1** (for motor encoders) or **S-0-0054, Reference distance 2** (for any other encoders).

Upon successful completion of command **P-0-0012, C300 Command 'Set absolute measurement',** the actual position value is set to that value entered in the relevant **Reference dimension** and after **S-0-0403**, **Position feedback value status** has been set to **"1"**.

**Control word setting the absolute dimension**

The execution of the command depends on **P-0-0612, Control word for setting absolute measurement** the absolute dimension. Bit 0 fixes whether the current coordinate system is retained even after the control voltage is switched on and off, i.e., whether the current **P-7-0514, Absolute encoder offset** is stored in the feedback data memory and is resistant to change.

**Note:** Given frequence “Setting of absolute dimension" bit 0 = 1 should be set as feedback data memory is only suited for a limited number of write accessing procedures.

For bits 1 and 2 the difference as to whether drive enable is given or not must be made.

**Parameter Structure:**

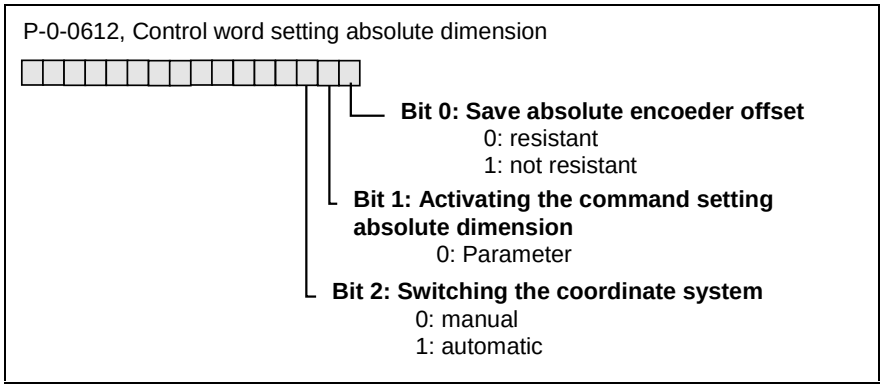

P-0-0612, Control word setting absolute dimension
Bit 0: Save absolute encoeder offset
0: resistant
1: not resistant
Bit 1: Activating the command setting absolute dimension
0: Parameter
Bit 2: Switching the coordinate system
0: manual
1: automatic

Fig. 9-106: P-0-0612, Control word setting the absolute dimension

**The command**

## "Setting the absolute dimension" without drive enable

Bit1 of **P-0-0612** is used to select whether the command is started

- by writing into parameter **P-0-0012** with "11b" (if bit1 ="0") or
- a 0->1 flank at the zero switch input (if bit1 ="1").

**Switching the co-ordinate system**

**Note:** **If the drive enable is not applied and command** "Setting the absolute dimension" is started, then drive-internally the co-ordinate system is always automatically and immediately switched (bit 2 is not relevant in this case!).

| Case | P-0-0612 | Behavior when executing the command |
|---|---|---|
| A1 | Bit1 = 0<br>Bit2 = x | Setting the absolute dimension by conducting **P-0-0012, C300 Command ’Set absolute measurement**<br>• by writing "11b" into **P-0-0012,** then, in addition to command start "Setting the absolute dimension", the co-ordinate system is also automatically switched. |
| B1 | Bit1 = 1<br>Bit2 = x | **Setting the absolute dimension with a 0-1 flank at the reference switch input**<br>• a 0->1 flank at zero switch input stores the actual position<br>• and the co-ordinate system is also immediately switched |

Fig. 9-107: Overview: setting the absolute dimension without drive enable

**Case A1:** When activating the command by writing into the parameter, proceed as follows:

- The axis must be brought into the precisely measured position.
- The actual position value of the position wanted must be entered.
- The command can be started by writing "11b" into **P-0-0012, C300 Command 'Set absolute measurement"**.
- The command immediately sets the actual position value of the measuring system to the reference dimension and the position status becomes "1". The drive completes the command which can now be cleared (**P-0-0012** ="0").

**Case B1:** Basically same procedure as with case A1, but the command is activated by the flank at the zero switch input.

---

**Note:** Bit1 of **P-0-0612** and the command itself are deleted automatically and drive-internally upon completion of "Setting the absolute dimension"!

---

## "Setting the absolute dimension" with drive enable

If the application uses a so-called "vertical axis" or the position approached without drive enable cannot, for whatever reason, be held, then the command can also be executed with drive enable.

**The command** With bit1 of **P-0-0612** it is set whether the command is started by

- writing "11b" into **P-0-0012** (bit 1 ="0") or
- a 0->1 flank at the zero switch input (bit 1 ="1").

---

**Note:** For safety reasons, flank evaluation is automatically deactivated after "Setting the absolute dimensions" has been completed. This means that applications in systems with slip must cyclically use bit 1 in **P-0-0612**.

---

**Switching the co-ordinate system** Use bit2 of **P-0-0612** to select whether, when executing command **P-0-0012, C300 Command Setting the absolute dimension,**

- there is also an immediate drive-internal switch of the co-ordinate system (bit 2 ="1") or
- the start of **S-0-0148, C600 Drive controlled homing procedure command** is delayed until the drive enable is removed by the control before the co-ordinate system is switched (bit 2 ="0").

| Case | P-0-0612 | Behavior when executing the command |
|---|---|---|
| C1 | Bit1 = 0<br>Bit2 = 0 | • By writing "11b" into **P-0-0012, C300 Command 'Set absolute measurement'"** the command is started but the co-ordinate system not switched.<br>• By starting the command **S-0-0148** or removing RF, the co-ordinate system is switched |
| C2 | Bit1 = 0<br>Bit2 = 1 | • By writing "11b" into **P-0-0012, C300 Command 'Set absolute measurement'"** the command is immediately started and the co-ordinate system switched |
| D1 | Bit1 = 1<br>Bit2 = 0 | • a 0->1 flank at the zero switch input stores the actual position<br>• and starts command **S-0-0148** but the control waits to switch the co-ordinate system! |
| D2 | Bit1 = 1<br>Bit2 = 1 | • a 0->1 at the zero switch input stores the actual position<br>• and immediately switches the co-ordinate system |

Fig. 9-108: Overview: setting the absolute dimension with drive enable

**Note:** Make sure that an encoder has been programmed in bit 3 of **S-0-0147, Homing parameter**.

**Case C1:** In the event that the co-ordinate system switch does not automatically take place drive-internally, (**P-0-0612,** bit 2 ="0"), then proceed as follows:

- take the axis to the measured position
- enter the actual position value wanted into the relevant reference dimension actual position value parameter
- Start command **P-0-0012, C300 Command 'Set absolute measurement'** (write "11b" into P-0-0012"). There is no switching of position data as yet.
- Start command **S-0-0148, C600 Drive controlled homing procedure command** or remove drive enable. This function recognizes that it is dealing with an absolute measuring system and conducts "Setting the absolute dimension". In other words, the actual position value is set to the reference dimension. The position command value is simultaneously set to the same value (**S-0-0047, Position command value**). If the drive is in "Position control" mode, then the position command value must be read via the acyclic parameter channel (e.g., service channel with SERCOS) and the position command value of the control set to this value before the referencing command is cleared.
- Clearing command "**C300 Set absolute measuring** the absolute **dimension"**

**Case C2:** In the event that the co-ordinate system is to be automatically and drive-internally switched at the start of command "Setting the absolute dimension" **(P-0-0612**, Bit 2 ="1**")** then proceed as follows:

- Bring the axis to the measured position.
- Enter the desired actual position value in the relevant reference dimension actual position value parameter.
- Start command **C300 Set absolute measuring** the absolute dimension (write "11b" into P-0-0012") and position data are also automatically switched.
- Drive-internally and automatically command **S-0-0148, C600 Drive controlled homing procedure command** is started. With command execution, the drive recognizes that it is dealing with an absolute measuring system and conducts "Setting the absolute dimension". In other words, the actual position value is set to the reference dimension. The position command value is simultaneously set to the same value (**S-0-0047, Position command value**). In position control mode this automatically leads to the automatic switch of the co-ordinate system, but as the control cannot bring its command value immediately up to the new actual value, there is an abrupt transition.
- Clear command **P-0-0012, C300 Command 'Set absolute measurement'.**

**Case D1:** In the event that the co-ordinate system switch is not automatic and drive-internal (**P-0-0621**, Bit 2 ="0"), then basically the same procedure as with case C1 should be followed, but the command is here activated by a flank at the zero switch input.

- Activate the zero switch input by setting **P-0-0612,** Bit1="1".
- Run the axis to the measured position (e.g., jog it there).
- and so on ...

---

**Note:** Both bit1 of **P-0-0612** and the command itself are automatically, drive-internally deleted after "Setting the Absolute Dimension"!

---

**Case D2:** If the co-ordinate system is to be switched drive-internally and automatically at the start of command "Setting the absolute dimension" **(P-0-0621,** Bit 2 ="1"), then basically proceed as with case C2 but here the command is activated by a flank at the zero switch input.

- Activate the zero switch input with **P-0-0612,** Bit1="1"
- Run the axis to the measured position (e.g., jog it there).
- and so on ....

---

**Note:** Both bit1 of **P-0-0612** and the command itself are automatically, drive-internally deleted after "Setting the absolute dimension"!

---

## Actual Position Value after Setting the absolute dimension

The state of the actual position value of the motor encoder, and any other encoders that might be mounted, after the execution of the setting the absolute dimension command depends on bit 3 in **S-0-0147, Homing parameter** and whether the absolute encoder is a motor or an optional encoder.

| Motor encoder | Optional encoder | S-0-0147 Bit 3: | Actual position value 1 | Actual position value 2 |
|---|---|---|---|---|
| absolute | not absolute or not there | any | Reference dimension 1 | Reference dimension 1 |
| not absolute | absolute | any | Reference dimension 2 | Reference dimension 2 |
| absolute | absolute | 0 | Reference dimension 1 | unchanged |
| absolute | absolute | 1 | unchanged | Reference dimension 2 |

Fig. 9-109: Actual position value after setting the absolute dimension

## Actual position value of absolute encoders after power on

(See section: "Actual position values of absolute measuring systems after initialization".)

## Diagnostic messages

While executing the command it is possible that command error "**C302 Absolute measuring system not installed**" is generated once command **P-0-0012, C300 Command 'Set absolute measurement'** is started without an absolute measuring system having been installed.

## Hardware Connections

See "project planning manual zero switch input (terminal X3 pin1).

## Notes

# 10 Optional Drive Functions

## 10.1 Configurable Signal Status Word

The configurable signal status word supports the acceptance of a maximum of 16 copies of bits from other drive parameters. This makes it possible for a user to put a bit list together which contains drive status information that is important to the control.

The signal status word can only be used in

- a free-configurable operating mode
- a free-expandable I/O mode.

**Note:** The bits in the signal status are put together in every command communication cycle at **S-0-0007, Feedback acquisition starting time (T4)**.

### Pertinent Parameters

These parameters are used with this function:

- **S-0-0144, Signal status word**,
  The desired bits are applied there.
- **S-0-0026, Configuration list signal status word,**
  ID number list with variable length to configure the bit strip.
- **S-0-0328, Assign list signal status word**
- Bit number list with variable length to configure the bit strip.

### Configuration of the Signal Status Word

**Configuration of the ID number**

The ID numbers of the parameters which contain the original bits (sources) are specified in parameter **S-0-0026, Configuration list signal status word.** The position of an ID number in the list determines the bit in the signal status word to which the ID number applies. So the first list element informs as to what parameter bit 0 of the signal status word comes from.

**Configuring the bit numbers**

Which bit of the parameters selected in **S-0-0026, Configuration list signal status word** is to be copied into the signal status word is determined in **S-0-0328, Assign list signal status word**.

**Note:** If this list remains empty, then bit 0 of the parameter is automatically copied. Otherwise, the bit taken out of the source parameter is specified here.

Bit number 0 (LSB) to 31 (MSB) can be specified. For each bit number of this list there must be an ID number in the same list position in list S-0-0026. Otherwise, the drive, when writing the bit number list, will issue the error message "ID number not available". This is why list **S-0-0026, Configuration list signal status word** must be written into before **S-0-0328, Assign list signal status word**.

**Example:** A signal status word with the following configuration must be put together:

| Bit no. in S-0-0144, Signal status word | ID number of original parameter | Bit no. of original parameter | Definition |
|---|---|---|---|
| 0 | S-0-0013 | 1 | Vist = 0 |
| 1 | S-0-0182 | 6 | IZP |
| 2 | S-0-0403 | 0 | position status |
| 3 | P-0-0016 | 4 | P-0-0015 specifying memory address of a drive-internal counter. Transmission is from bit 4. |

Fig. 10-1: Example of a configurable signal status word

**Signal status word output** Bits 0 – 9 of parameter **S-0-0144, Signal status word** are copied in the DKC01.3 to the digital outputs (X15.14-24).

**Note:** A maximum of 16 bits can be configured. Configuration is performed from the least-significant to most-significant bit. In other words, the position of the bit copy in the signal status word is the result of the continuous configuration in S-0-0026.

## Diagnostic / Error Messages

The following checks are run when inputting parameters **S-0-0328, Assign list signal status word** or **S-0-0026, Configuration list signal status word**:

- If more elements are programmed in **S-0-0328, Assign list signal status word** than **S-0-0026, Configuration list signal status word** then error message "*0x1001, ID number not available*" is generated.
- If an ID number specified in **S-0-0026, Configuration list signal status word** does not exist, then error message "*0x1001, ID number not available*" is generated.
- Check whether the IDN variable data length (list parameters) specified in **S-0-0026, Configuration list signal status word** exists or a so-called online read function. Parameters with online read function are generally parameters with physical units (position, speed, acceleration and currents) as well as parameters **S-0-0135, Drive status word** and **S-0-0011, Class 1 diagnostics**. If yes, then service channel error message *0x7008, Data not correct* is generated.

**Note:** In each of these cases, only the inputs up until the faulty element is accepted!

# 10.2 Configurable Signal Control Word

With the signal control word it is possible to write access single control bits in the various parameters by using a freely-configurable collective parameter.

The configurable signal control word supports acceptance of a maximum of16 copies of bits from other drive parameters.

**Accessing signal control word**

Depending on the **command communications** parameter **S-0-0145, Signal control word** is accessed in various ways:

- With SERCOS and fieldbus interface,**S-0-0145, Signal control word** must be relevantly configured in cyclical data so that the mechanism can be used.

This function can only be used in

- free-configurable operating mode.

**Note:** The bits in the signal control word are effective in each interface cycle at **S-0-0008, Command valid time (T3).**

## Involved Parameters

The following parameters are used for the functions

- **S-0-0027, Configuration list signal control word**
- **S-0-0329, Assign list signal control word**
- **S-0-0145, Signal control word**
- **S-0-0399, IDN list of configurable data in the signal control word**

## Configuring the Signal Control Word

**Selection lists**

Only those parameters in list **S-0-0399, IDN list of configurable data in the signal control word** can be allocated to configuration list **S-0-0027, Configuration list signal control word**.

**Configuration of the ID numbers**

The ID numbers of the parameters which are to be configured with the help of the signal control word (=target) are specified in parameter **S-0-0027, Configuration list signal control word.**

The position of an ID number in the list determines which bit in the signal control word is allocated to which ID number (target). For example, the first list element fixes which parameter bit 0 of the signal control word is allocated to.

**Configuration of the bit numbers**

Which bit of the selected parameters (=target in **S-0-0027, Configuration list signal control word)** is set by the signal control word (or reset) is set in **S-0-0329, Assign list signal control word**.

**Note:** If this list remains empty, then bit 0 is automatically set in the specified parameters. Otherwise, the bit which is allocated to the target parameters is specified here.

Bit numbers from **0 (LSB) to 31 (MSB)** are entered here.

**Exceptions**

If the allocated parameter is a command, then the bit number in parameter **S-0-0329, Assign list signal control word** is not relevant.

If the allocated parameter is parameter **S-0-0346, Setup flag for relative command values**, then a positive edge in the relevant bit of the control word effects a toggling of the parameter **S-0-0346, Setup flag for relative command values**.

**ID number not available**

For every bit number in list **S-0-0329, Assign list signal control word** there must be an ID number at the same list position in the list in **S-0-0027, Configuration list signal control word**. Otherwise, when writing the bit number list from the drive, error message "ID number not available" will be generated.

---

**Note:** This is why list S-0-0027 must be written prior to list S-0-0329.

---

**Example:**

| Bit no. In S-0-0145 | ID number of the target parameter | Bit no. of the target parameter | Definition |
|---|---|---|---|
| 0 | P-0-4026 | 0 | select positioning block |
| 1 | P-0-4026 | 1 | select positioning block |
| 2 | P-0-4026 | 2 | select positioning block |
| 3 | P-0-4026 | 3 | select positioning block |
| 4 | P-0-4026 | 4 | select positioning block |
| 5 | P-0-4026 | 5 | select positioning block |
| 6 | S-0-0346 | 0 | start (strobe) |
| 7 | S-0-0148 | 0 | start referencing command |
| 8 | P-0-4056 | 0 | jog positive |
| 9 | P-0-4056 | 1 | jog negative |

Fig. 10-2: Example for configuration signal control word ( = default setting)

Parameters **S-0-0027, Configuration list signal control word** and **S-0-0329, Assign list signal control word** must be configured as follows to obtain the wanted assignment of the control word.

---

**Note:** Up to **16 Bits** can be configured. Configuration takes place from the lowest to the highest value bit. In other words, The position of the bit copy in the signal control word is derived from the continuous configuration in S-0-0027.

---

## Diagnostic / Error Messages

When inputting one of the parameters (S-0-0027 or S-0-0329) the following checks are run:

- If more elements are programmed in **S-0-0329, Assign list signal control word** then in **S-0-0027, Configuration list signal control word**, then error message "*0x1001, ID number not available*" is generated.
- If an ID number specified in **S-0-0027, Configuration list signal control word** is not available, then error message "*0x1001, ID number not available*" is generated.
- If an ID number specified in **S-0-0027, Configuration list signal control word** is not on the list of the configured data S-0-0399 then error message "*0x7008, Data not correct"* is generated.

**Note:** In each of these cases, only that input prior to the faulty element will be accepted!

# 10.3 Analog Output

With the help of the function "Analog output" drive-internal signals and state variables can be generated as analog voltage signals. These can be examined with an oscilloscope connected to the analog outputs.

The conversion of the digital values from the drive is done via two 8 bit digital-to-analog converters. The maximum output voltage equals +/- 10 volts. There is an output every 500 usec.

## Possible output functions

1. Direct writing into the analog outputs
2. Assigning ID numbers to analog outputs
3. Output of pre-set signals
4. Byte output of RAM memory cell
5. Bit output of RAM memory cells

To parametrize the function, the following parameters are available:

- **P-0-0139, Analog output 1**
- **P-0-0140, Analog output 2**
- **P-0-0420, Analog output 1, signal selection**
- **P-0-0421, Analog output 1, expanded signal selection**
- **P-0-0422 Analog output 1, scaling**
- **P-0-0423, Analog output 2, signal selection**
- **P-0-0424, Analog output 2, expanded signal selection**
- **P-0-0425, Analog output 2, scaling**
- **P-0-0426 Analog outputs, IDN list of assignable parameters**

## Direct analog outputs

With the parameters **P-0-0139, Analog output 1** and **P-0-0140, Analog output 2** it is possible for the control to use the two 8 bit digital/analog converters of the drive. Voltage values written into these parameters, ranging between -10.000 volts and +10.000 volts, are output by the drive to the analog outputs. The quantization equals 78 mV.

A precondition for the use of an analog output is that the signal selection (P-0-0420 or P-0-0423) and the expanded signal selection (P-0-0421 or P-0-0424) were deactivated by inputting 0 for the used channel.

## Analog output of existing parameters

**selection list**

All parameters in the list **P-0-0426 Analog output, IDN list of assignable parameters** can be output analog.

**configuration**

This first requires that their ID number be input in the signal select for channel 1 (P-0-0420) or 2 (P-0-0423). The unit and the attribute (number of decimal places) of the relevant scaling (P-0-0422 or P-0-0425) is set as per the selected parameter. If the selected parameter depends on a scaling mode, then the settings there apply to the scaling as well.

**scaling**

With **P-0-0422 Analog output 1, scaling** or **P-0-0425, Analog output 2, scaling** is it then fixed at what value 10 volts are output.

For example, for rotary preferred position scaling and signal selection position command (S-0-0047), the unit of the scaling factor is set to degrees, and the number of decimal places is set to four. Inputting 90.0000 degrees in the evaluation factor means that 10 volts per 90 degrees at the load will be output .

If signals with a binary format are selected (e.g., **S-0-0134, Master control word)** then the display format of the scaling is set to decimal without fractional part. There is no unit. With this scaling, a bit number between 0 and 15 is selected. The state of this bit of the set parameter is then output in such a way that for logical 0 -10 volts are output and for logical 1 +10 volts (bit output).

## Outputting pre-set signals

To be able to show such signals in an analog manner, which do not exist as a parameter, there a way to select these via predefined signal numbers and to output these via the expanded analog output.

The parameters

- **P-0-0421, Analog output 1, expanded signal selection** and
- **P-0-0424, Analog output 2, expanded signal selection**

do the selection.

**Activation of the expanded output**

The expanded output only functions if the signal select for the channel used (P-0-0420 or P-0-0423) is deactivated by inputting the ID number 0.

The following list shows which signal is output with which signal number.

| Signal number P-0-0421/424 | Output signal | Reference unit: Evaluation factor 1.0000 |
|---|---|---|
| 0x00000001 | motor encoder sine signal | 0.5V/10V |
| 0x00000002 | motor encoder cosine signal | 0.5V/10V |
| 0x00000003 | Opt. enc. sine signal | 0.5V/10V |
| 0x00000004 | Opt. enc. sine cosine | 0.5V/10V |
| 0x00000005 | Position command difference on the pos. controler | rot. ⇒ 1000rpm/10V<br>lin. ⇒ 100m/min/10V |
| 0x00000006 | DC bus power | 1kW/10V |
| 0x00000007 | absolute DC bus power amount | 1kW/10V |
| 0x00000008 | effective current | S-0-0110/10V |
| 0x00000009 | relative current | S-0-0110/10V |
| 0x0000000a | thermal load | 100 % / 10V |
| 0x0000000b | motor temperature | 150°C/10V |
| 0x0000000c | magnetizing current | S-0-0110/10V |
| 0x0000000d | velocity command at the velocity controller | rot. ⇒ 1000rpm/10V<br>lin. ⇒ 100m/min/10V |
| FREE | | |
| FREE | | |
| ... | | |
| 0x00000014 | synchronous position command value | rot. => 360°/10V<br>lin. => 1mm/10V |
| 0x00000015 | synchronous velocity | rot. => 1000rpm/10V<br>lin. => 100m/min/10V |
| 0x00000016 | master axis position fine interpolation | 2^20/10V |
| 0x00000017 | master axis speed in the NC cycle | rot. => 1000rpm/10V |

Fig. 10-3: Signal selection list with pre-defined signal selection

See also "Control loop structure in chapter General Information for Control Loop Settings"

This information is scaling independent and always relates project planning manualthe motor shaft. The scaling of the signals is possible via the parameters **P-0-0422 Analog output 1, scaling** and **P-0-0425 Analog output 2, scaling.** These have been set as factors with 4 decimal places in the expanded signal selection. If the evaluation factors are 1.0000, then the standards specified in the table apply.

**Example:** Output of the position command difference with a value of 150rpm/10V on channel 1.

Input:

**P-0-0420, Analog output 1, signal selection** = S-0-0000

**P-0-0421, Analog output 1, expanded signal selection** = 0x00000005

**P-0-0422 Analog output 1, scaling** = 0.1500

## Bit and byte outputs of the data memory

**Note:** Use of this feature is meaningful only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the corresponding developer.

**activation of the bit and byte output**

The bit and byte output is only possible if the signal selection for the used channel (P-0-0420 or P-0-0423) is deactivated by inputting the ID number 0.

**configuration**

The selection of the function and the storage address takes place in the parameters

- **P-0-0421, Analog output 1, expanded signal selection** and
- **P-0-0424, Analog output 2, expanded signal selection.**

In the high nibble (half byte with bits 28..31), byte output is activated with a 1 and bit output with a 2. The least significant 24 bit of the parameter inputs the storage address.

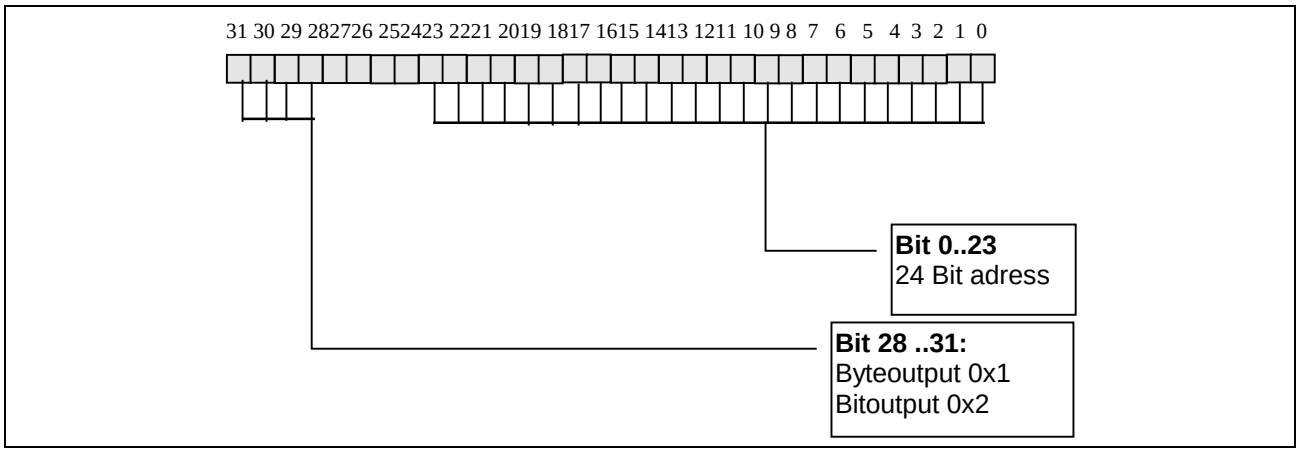



Fig. 10-4: Parametrizing bit or byte output

**scaling**

The parameters **P-0-0422 Analog output 1, scaling** and **P-0-0425 Analog output 2, scaling** either select the bit to be output or it can be determined from which (least signifiant) bit on the byte to be generated will start. When selecting the bit number, only values between 0 and 15 make sense. If greater values are entered, then only bits 0..3 are used.

When outputting bits, -10 volt (bit = 0) or +10 volt ( bit = 1) is output.

**Byte output**

With byte outputs, the MSB of the byte to be output is interpreted as sign bit. Voltages ranging from -10 to +10 volts are output.

## Terminal assignment - analog output

see project planning manual.

# 10.4 Analog Inputs

Using the function "Analog inputs", two analog inputs can be used via analog/digital converters in one parameter each. The analog voltages, in the form of both of these parameters, can then either be

- transmitted to the control and supports the control as an analog input function or
- it can be assigned in the drive to a different parameter taking a settable scaling and a settable offset into account.

**Note:** With the help of analog inputs it is also possible to set specific command values for velocity control mode.

## Pertinent Parameters

The following parameters are available for the function:

- **P-0-0210, Analog input 1**
- **P-0-0211, Analog input 2**
- **P-0-0212, Analog inputs, IDN list of assignable parameters**
- **P-0-0213, Analog input 1, Assignment**
- **P-0-0214, Analog input 1, Scaling per 10V**
- **P-0-0215, Analog input 2, Assignment**
- **P-0-0216, Analog input 2, Scaling per 10V**
- **P-0-0217, Analog input 1, Offset**
- **P-0-0218, Analog input 2, Offset**

## Functional principle of the analog inputs

The two analog inputs are connected over two **differential inputs** E1+ / E1- and E2+ / E2- .

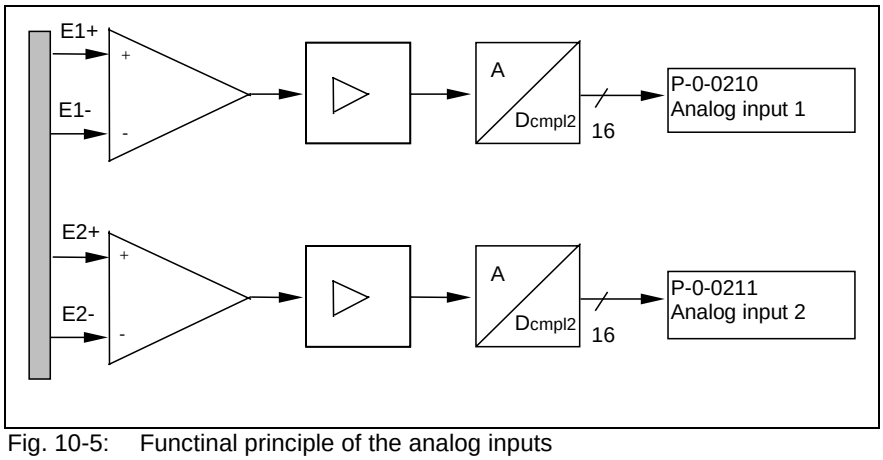



Fig. 10-5: Functinal principle of the analog inputs

The digitalized voltages of both differential inputs are displayed in the parameters **P-0-0210, Analog input 1** and **P-0-0211 Analog input 2.**

**Assignment of analog inputs to parameters**

Both **P-0-0210, analog input 1** and **P-0-0211 analog input 2**, which depict the analog-to-digital converted voltages, can be assigned to other drive parameters, i.e., they can be cyclically copied while taking

- an offset and
- a selectable scaling

into account.

**Processing of analog inputs**

- Analog channel 1 **is processed every 500 µs**
- Analog channel 2 **is processed every 8 ms**

---

**Exception:** In modes "velocity control" or "torque control", the command values are read every **500 µs**.

---

The assignment applies the following principle:

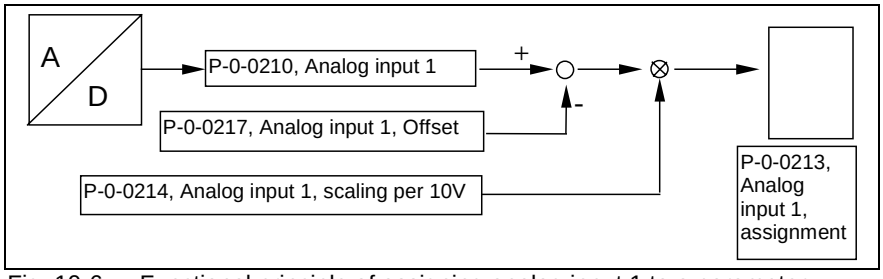



Fig. 10-6: Functional principle of assigning analog input 1 to a parameter

**Displaying analog value 1**

The converted voltage signals of both differential inputs are stored in parameter **P-0-0210, Analog input 1** respectively.

**Configuring the analog input 1**

An assignment of an analog input to a parameter is activated if in parameter **P-0-0213, Analog input 1, assignment** a value not equal to S-0-0000 has been parametrized. The contents of **P-0-0210, Analog input 1** minus the contents of **P-0-0217, Analog input 1, Offset** is scaled with the scaling factor set in **P-0-0214, Analog input 1, Scaling per 10V** and then copied into the parameter with the ID number set for the assignment in **P-0-0213, Analog input 1, Assignment**.

**Evaluation parameter unit**

The **unit** of the parameter **P-0-0214, Analog input 1, Scaling per 10V** complies with the unit of the assigned parameter.

**Selection list**

Only those parameters can be assigned that are listed in **P-0-0212, Analog inputs, IDN list of assignable parameters**.

**Configuring analog input 2**

---

**Note:** The configuration or allocation of analog input 2 can be conducted accordingly.

---

**Example:**

Assignment of analog input 1 to **S-0-0036, velocity command value** with 10 V equal to 1000 rpm

Parameter setting:

**P-0-0213, analog input 1** = S-0-0036

**P-0-0214, analog input 1, evaluation per 10V** = 1000.0000 rpm

## Analog Inputs - Connection

See also project planning manual.

# 10.5 Digital Output

The drive controller has two digital outputs available to it with the basic unit independent of command communications.

## Pertinent Parameters

- **P-0-0124, Assign IDN -> Digital output**
- **S-0-0097, Mask class 2 diagnostic**

## Functional Principle

With parameter **P-0-0124, Assignment IDN -> Digital output** it is possible to assign any parameter to these outputs.

**Parameter structure P-0-0124:** This parameter is a 4 byte parameter. The lowword contains the ID number of the assigned parameter, the highword the number of digital interfaces.

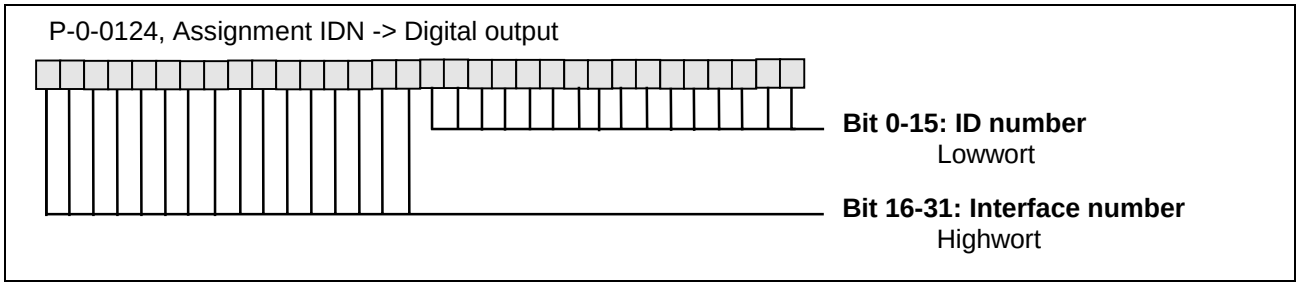



Fig. 10-7: P-0-0124, Assignment IDN -> Digital output

**Example:**

Parameter S-0-0144 is to be brought to the digital outputs of the drive controller.

1. interface number = 1 -> highword =1
2. ID number = S-0-0144 –> lowword = 0x90

The value 0x10090 must therefore be written into P-0-0124.

**Note:** With a DKCx.3 the number of digital interfaces is always 1.

If ID number = 0 in P-0-0124 is entered, then the drive automatically puts the READY signal (power section ready and no error) and WARNING (one bit of class 2 diagnostics is set and masked with S-0-0097) on the outputs.

## Hardware Requirements

**DKC**.3** The following applies with a DKC**.3:

**P-0-0124, Assignment IDN -> Digital output**

Bit 0 (*) => output X3/8

Bit 1 (*) => output X3/10

(*) the data of the assigned ID number.

**DKC01.3**

**Note:** The freely configurable signal status word are assigned to digital outputs X15/14 to X15/23 in a DKC01.3.

# 10.6 Oscilloscope Feature

The oscilloscope feature is used to diagram internal and external signals and output variables. Its function is comparable to a 2-channel oscilloscope. The following parameters are available to set the oscilloscope feature:

- **P-0-0021, List of Scope Data 1** (always 4-byte data)
- **P-0-0022, List of Scope Data 2** (always 4-byte data)
- **P-0-0023, Signal Select Scope Channel 1**
- **P-0-0024, Signal Select Scope Channel 2**
- **P-0-0025, Trigger Source**
- **P-0-0026, Trigger Signal Selection**
- **P-0-0027, Trigger Level for Position Data**
- **P-0-0028, Trigger Level for Velocity Data**
- **P-0-0029, Trigger Level for Torque/Force Data**
- **P-0-0030, Trigger Edge**
- **P-0-0031, Timebase**
- **P-0-0032, Size of Memory**
- **P-0-0033, Number of Samples after Trigger**
- **P-0-0035, Delay from Trigger to Start** (cannot be written)
- **P-0-0036, Trigger Control Word**
- **P-0-0037, Trigger Status Word**
- **P-0-0145, Expanded Trigger Level**
- **P-0-0146, Expanded Trigger Address**
- **P-0-0147, Expanded Signal K1 Address**
- **P-0-0148, Expanded Signal K2 Address**
- **P-0-0149, List of selectable signals for oscilloscope function**
- **P-0-0150, Number of valid Samples for Oscilloscope Function**

# Main Functions of the Oscilloscope Feature

The oscilloscope feature can be activated with the parameter **P-0-0036, Trigger Control Word** by setting bit 2. From then on, all data will be recorded that was selected through the parameters **P-0-0023, Signal Selection Channel 1** and **P-0-0024 Signal Selection Channel 2**. The selection will be defined with numbers that are assigned to various signals.

The triggering is activated by setting the bit 1 in the "Trigger Control Word" parameter. The trigger conditions can be set with the parameters **P-0-0025, Trigger Source, P-0-0026, Trigger Signal Selection** and **P-0-0030 Trigger Edge**. The signal amplitude that releases the trigger can be set with the parameters **P-0-0027 - P-0-0029 Trigger Level**.

If a trigger event is recognized, then the number of values in the parameter **P-0-0033 Number of Samples after Trigger** will be recorded, and the function will end. Parameters **P-0-0031 Timebase** and **P-0-0032 Size of Memory** can define the recording duration and the time intervals for the measurement samples.

The sampled values are stored in **P-0-0021 and P-0-0022 List of scope data** and can be read by the control.

# Parameterizing the Oscilloscope Feature

## Oscilloscope feature with defined recording signals

Preset signals and state variables can be selected through the **P-0-0023 and P-0-0024 Signal Selection** parameters. The selection can be made by entering the signal number (hex format) in the corresponding signal selection parameter. The selected signal number defines the unit of data stored in the list of scope data. The following signals are predefined with numbers.

| Number: | Signal selection: | Unit of the probe value list: |
|---|---|---|
| 0x00 | Channel not activated | -- |
| 0x01 | Actual position feedback value dependent on operating mode S-0-0051 or S-0-0053 | dependent on position scaling |
| 0x02 | Velocity feedback value Parameter (S-0-0040) | velocity scaling dependent |
| 0x03 | Velocity control deviation (S-0-0347) | velocity scaling dependent |
| 0x04 | Following error Parameter (S-0-0189) | dependent on position scaling |
| 0x05 | Torque/force command value Parameter S-0-0080 | Percent |
| 0x06 | Position feedback 1 value S-0-0051 | dependent on position scaling |
| 0x07 | Position feedback 2 value S-0-0053 | dependent on position scaling |
| 0x08 | Position command value S-0-0047 | dependent on position scaling |
| 0x09 | Velocity command value Parameter (S-0-0036) | velocity scaling dependent |

Fig. 10-8: Selection of predefined signals

**Note:** Parameter **P-0-0149, List of selectable signals for oscilloscope function** was introduced so that the control can detect the number of preset numbers. This parameter is constructed in terms of a list parameter and transmits the ID numbers of the possible signals.

## Expanded Oscilloscope Recording Function

In addition to the oscilloscope feature with preset signals, the drive also allows for recording of any desired internal signals. Use of this feature is meaningful only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the corresponding developer. The feature can be activated with the **Signal Selection P-0-0023 & P-0-0024** parameters by setting bit 12 = "1". The format for the data to be saved can be defined with bit 13.

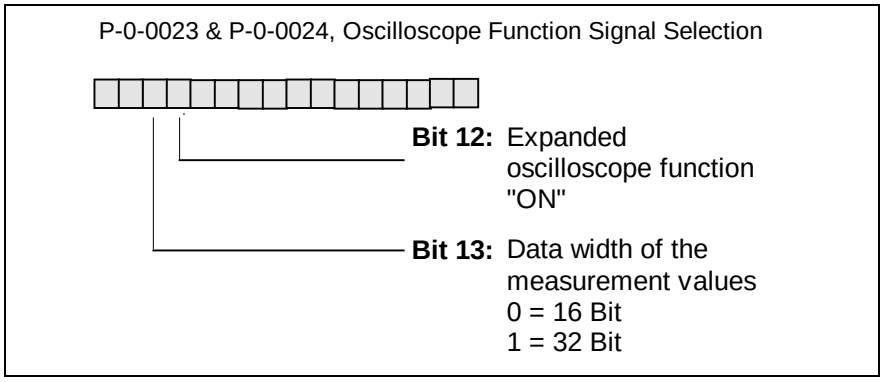

P-0-0023 & P-0-0024, Oscilloscope Function Signal Selection
Bit 12: Expanded oscilloscope function "ON"
Bit 13: Data width of the measurement values
0 = 16 Bit
1 = 32 Bit

Fig. 10-9: Structure of Parameters P-0-0023 and P-0-0024

If the expanded signal selection is parameterized, then the desired signal address can be defined in parameters **P-0-0147, Expanded signal K1 address** and **P-0-0148, Expanded signal K2 address**. During the recording process, the contents of the selected addresses are saved in the lists of scope data.

**Note:** If a 16-bit data width is selected, then the signal data will be stored as sign-extended 32-bit values.

## Oscilloscope Feature Trigger Source

The **P-0-0025 Trigger Source** parameter makes it possible for the user to choose between two trigger types.

**External trigger (P-0-0025 = 0x01)**

The trigger is activated by the control through bit 0 in the **Trigger Control Word**. This makes it possible to transmit a trigger event to several drives. This parameterization supports parameter P-0-0035, which is needed to visualize the recording data.

**Internal trigger (P-0-0025 = 0x02)**

Triggering occurs through the monitoring of the parameterized trigger signal. If the selected edge is recognized, then the trigger will be released. The "Delay from Trigger to Start" parameter will be set to zero.

## Selection of Trigger Edges

Various trigger edges can be selected with the parameter **P-0-0030 Trigger Edge**. The following options are available:

| Number: | Trigger Edge: |
|---|---|
| 1 | Triggering on the positive edge of the trigger signal |
| 2 | Triggering on the negative edge of the trigger signal |
| 3 | Triggering on both the positive and negative edge of the trigger signal |
| 4 | Triggering when the trigger signal equals the trigger level |

Fig. 10-10: Trigger edge selection

## Selection of Fixed Trigger Signals

The parameter **P-0-0026 Trigger Signal Selection** determines the signal that is monitored for the parameterized edge reversal. Just as for the signal selection, there are drive-internal fixed trigger signals for the trigger signal selection. These are activated by entering the corresponding number.

The following signal numbers are possible:

| Trigger signal number: | Trigger signal: | Associated trigger edge: |
|---|---|---|
| 0x00 | no trigger signal | not defined |
| 0x01 | Actual position feedback according to active operating mode | Position data (P-0-0027) |
| 0x02 | Velocity feedback value Parameter S-0-0040 | Velocity data (P-0-0028) |
| 0x03 | Velocity deviation Parameter S-0-0347 | Velocity data (P-0-0028) |
| 0x04 | Following error Parameter S-0-0189 | Position data (P-0-0027) |
| 0x05 | Torque command value Parameter S-0-0080 | Torque data (P-0-0029) |

Fig. 10-11: Selection of fixed trigger signals

## Selection of Expanded Trigger Signals

In addition to a trigger signal selection with preset signals, the drive also allows for triggering on any desired internal signal. Use of this feature is meaningful only with information about the structure of the internal data memory; therefore, this feature can be used effectively only by the corresponding developer. This feature can be activated with the parameter **P-0-0026 Trigger Signal Selection** by setting bit 12 to 1.

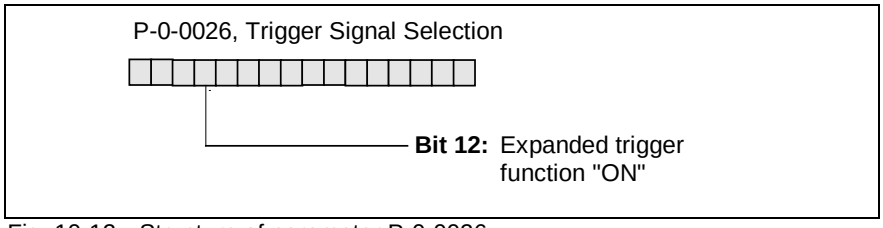



Fig. 10-12: Structure of parameter P-0-0026

If the expanded trigger feature is activated, then the trigger signal address must be defined via the parameter **P-0-00146 Expanded Trigger Address**. The associated trigger level is entered in the parameter **P-0-0145 Expanded Trigger Level**.

This parameter is defined as follows:

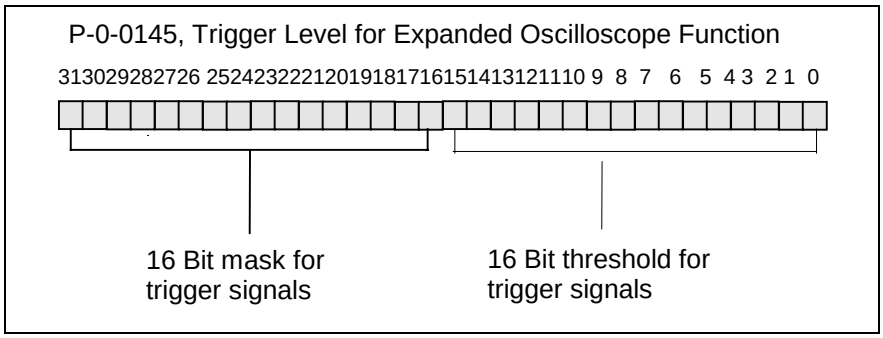

P-0-0145, Trigger Level for Expanded Oscilloscope Function
313029282726 25242322212019181716151413121110 9 8 7 6 5 4 3 2 1 0
16 Bit mask for trigger signals
16 Bit threshold for trigger signals

Fig. 10-13: Structure of parameter P-0-0145

The 16-bit value of the trigger edge is monitored and the trigger signal will be ANDed with the trigger signal screen mask.

## Setting the Time Resolution and the Memory Depth

The recording ranges for the oscilloscope feature can be defined with parameters **P-0-0031, Timebase** and **P-0-0032, Size of Memory**. The maximum memory depth is 512 samples. If you need fewer samples, you can change the value in the memory size parameter.

The time resolution can be set from 500 µs to 100 ms in steps of 500 µs. This determines the time intervals in which the samples are recorded. The minimum recording duration is 256 ms; the maximum recording duration is 51.2 s.

In general:

$$\text{Recording duration} = \text{Time resolution} \times \text{Size of Memory}\,[\mu s]$$

Fig. 10-14: Determining of the recording duration

## Setting the Trigger Delays

By setting the parameter **P-0-0033 Number of Samples after Trigger**, it is possible to record probe values before the trigger event occurs (trigger delay function of an oscilloscope). The setting occurs in units of the parameterized time resolution. The input value determines the number of probe values still recorded after a trigger event. By entering 0 • [time resolution], only data available before a trigger event will be recorded. If the value of the P-0-0032 Size of Memory parameter is entered, then only the probe values occurring after the trigger event will be recorded.

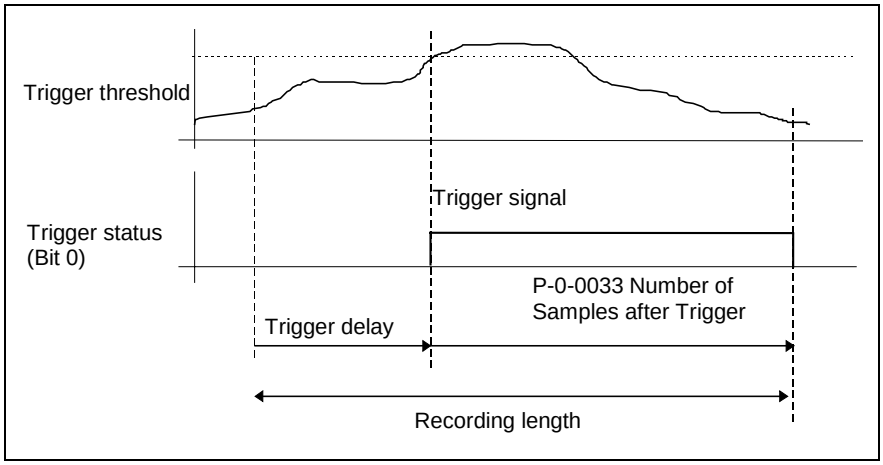



Fig. 10-15: Trigger delay - Number of samples after trigger

## Activating the Oscilloscope Feature

The oscilloscope feature can be activated with the parameter **P-0-0036 Trigger Control Word**. The parameter is defined as follows:

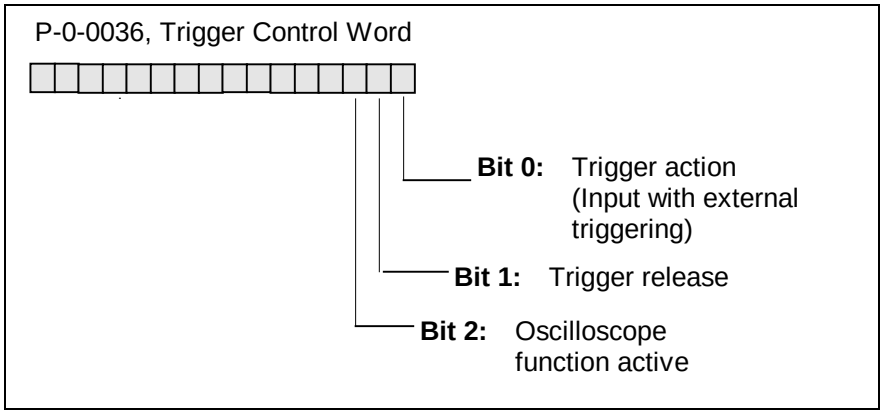

P-0-0036, Trigger Control Word
Bit 0: Trigger action (Input with external triggering)
Bit 1: Trigger release
Bit 2: Oscilloscope function active

Fig. 10-16: Structure of Parameter P-0-0036

The oscilloscope feature is activated by writing "1" into bit 2; i.e., the internal probe value memory is continually written with the selected measurement signals. If bit 1 is set, then the trigger monitor is activated, and the oscilloscope feature waits for the selected edge to occur. If a valid edge is recognized, then the probe value memory will be completed as set in parameter P-0-0033, and the oscilloscope feature will be deactivated by resetting bits 1 & 2 in the trigger control word.

## Oscilloscope Feature With External Trigger and Internal Trigger Condition

If triggering is selected in parameter **P-0-0025 Trigger Source** with the control bit of the trigger control word, then the trigger will be initiated with the 0→1 (rising) edge of bit 0 in the trigger control word.

With this drive, it is also possible to monitor a trigger signal for the trigger condition. If the trigger condition is recognized, then bit 0 will be set in the trigger status, but it will not trigger. In this way, it is possible to signal the trigger event for several drives simultaneously using the real-time status and control bits via the control and to release the trigger.

Since there is a delay between the recognition of the trigger event and the enabling of this trigger, the delay is measured by the drive controller and stored in the parameter **P-0-0035, Delay from Trigger to Start**. A time-correct display of the signal can be guaranteed by using this parameter for the visualization of the probe values.

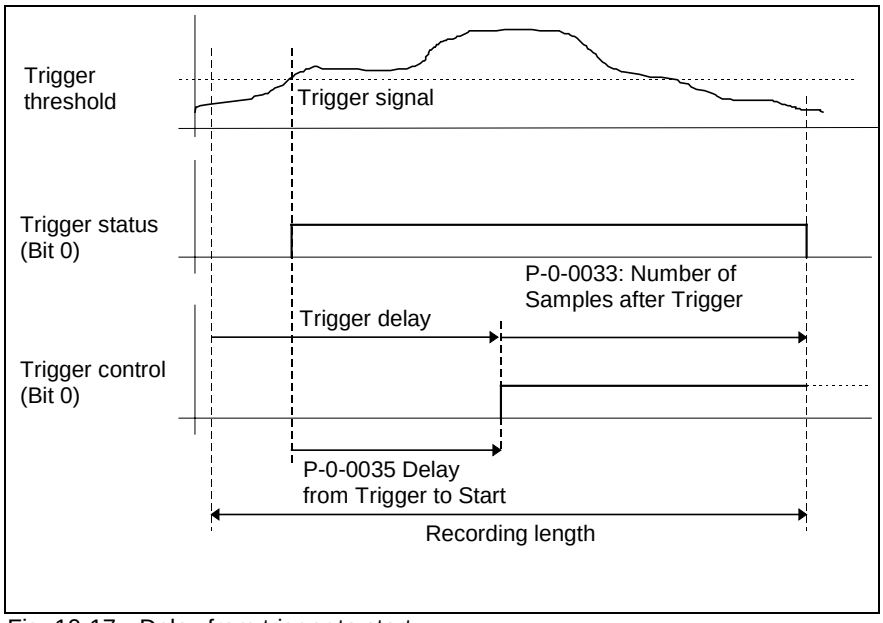



Fig. 10-17: Delay from trigger to start

## Status Messages for the Oscilloscope Feature

Information about the status of the oscilloscope feature is shared with the control by means of parameter **P-0-0037, Trigger Status Word**.

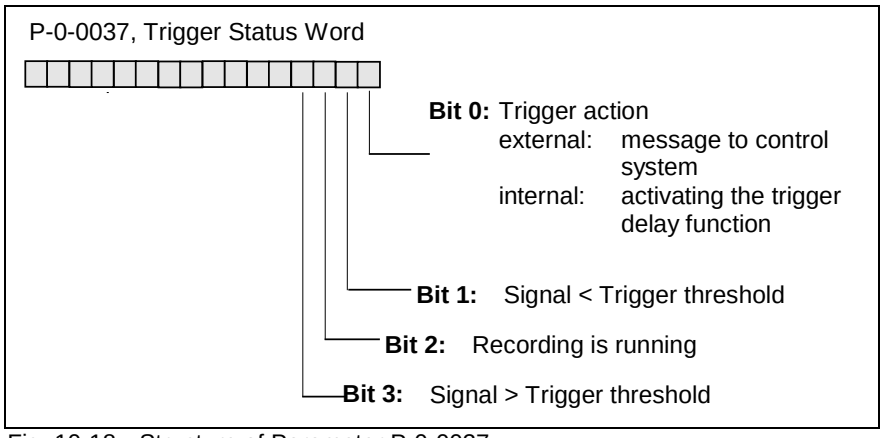



Fig. 10-18: Structure of Parameter P-0-0037

## Number of Valid Probe Values

As soon as bit 2 is set by the **P-0-0036, Trigger Control Word**, the drive starts to record probe values.

If the trigger event is recognized after the bit is set, the oscilloscope feature records the number of samples after the trigger event and then stops recording.

The total probe value memory for the current measurement will not always be written, dependent on the memory size setting, the time resolution, the number of samples after trigger and the time when the trigger event occurs.

This means that the memory can contain samples which are not valid for the measurement.

The parameter **P-0-0150, Number of valid Samples** indicates the number of valid samples for the current recording.

# 10.7 Probe Input Feature

Two digital inputs are available for measuring positions and times. The measured values are determined at the time of the positive and negative edge.

The following measured values can be determined:

- actual position value 1
- actual position value 2
- relative internal time in [usec]
- master axis position
- actual feedback value 3

**Note:** The probe inputs are probed every 1 µsec. The measured signals are generated every 500 µsec. Linear interim interpolation takes place between these two steps with an accuracy of 1 µsec.

You can read the absolute values of these signals at the time of a positive or negative edge as well as their difference by parameters.

## Pertinent Parameters for the Probe Analysis

- **S-0-0170, Probing cycle procedure command**
- **S-0-0401, Probe 1**
- **S-0-0402, Probe 2**
- **S-0-0169, Probe control parameter**
- **P-0-0200, Signal select probe 1**
- **P-0-0201, Signal select probe 2**
- **P-0-0204, Start position for active probe**
- **P-0-0205, End position for active probe**
- **S-0-0405, Probe 1 enable**
- **S-0-0406, Probe 2 enable**
- **S-0-0130, Probe value 1 positive edge**
- **S-0-0131, Probe value 1 negative edge**
- **S-0-0132, Probe value 2 positive edge**
- **S-0-0133, Probe value 2 negative edge**
- **P-0-0202, Difference Probe Values 1**
- **P-0-0203, Difference Probe Values 2**
- **S-0-0409, Probe 1 positive latched**
- **S-0-0410, Probe 1 negative latched**
- **S-0-0411, Probe 2 positive latched**
- **S-0-0412, Probe 2 negative latched**

## Main Function of the Probe Analysis

The function is activated by setting and enabling **S-0-0170, Probing cycle procedure command** . The change bit command is never set as there is neither a positive nor negative command acknowledge.

To activate the feature, S-0-0170 must be written with 3 (decimal) = 11 binary.

From this point on, the status of the probe signals will be displayed in the parameters **S-0-401, Probe 1** and **S-0-402, Probe 2**.

A probe input is enabled with parameter **S-0-0405, Probe 1 enable** or **S-0-0406, Probe 2 enable**. With a 0-1 switch of the signal, the trigger mechanism is activated to evaluate the positive and/or negative edge of the probe signal.

It must be set in parameter **S-0-0169, Probe control parameter** which probe inputs are to be evaluated and whether the positive or negative flanks.

From this point on, when a probe signal edge is recognized, the selected signal will be stored in the positive or negative probe value parameter. At the same time, the difference between the positive probe value and the negative probe value will be computed and saved in the probe value difference parameter. The following status messages will be set to 1: **S-0-0409, Probe 1 positive latched** and **S-0-0410, Probe 1 negative latched** or **S-0-0411, Probe 2 positive latched** and **S-0-0412, Probe 2 negative latched**.

When the probe enable is cancelled, the following status messages will be erased: **S-0-0409, Probe 1 positive latched** and **S-0-0410, Probe 1 negative latched** or **S-0-0411, Probe 2 positive latched** and **S-0-0412, Probe 2 negative latched**.

---

**Note:** Only the first positive and the first negative signal edge of the input will be evaluated after the 0→1 (rising) edge of the probe enable. For each new measurement, the probe enable must be reset to 0 and then to 1. When the probe enable is cancelled, the corresponding probe-value latched parameters are also cancelled.

---

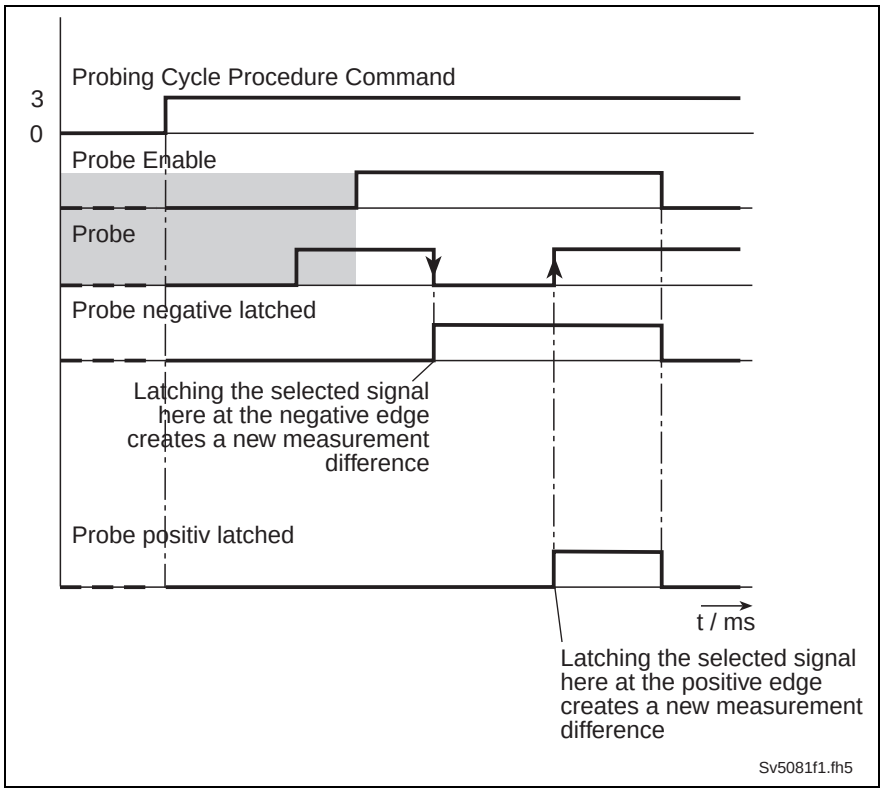

Probing Cycle Procedure Command
3
0
Probe Enable
Probe
Probe negative latched
Latching the selected signal here at the negative edge creates a new measurement difference
Probe positiv latched
t / ms
Latching the selected signal here at the positive edge creates a new measurement difference
Sv5081f1.fh5

Fig. 10-19: Evaluation of probe signal edges, when positive and negative signal edge evaluation are set in the probe control parameter

### Results of Writing "3" to the S-0-0170, Probing Cycle Procedure Command

The probe feature begins when 3 (decimal) = 11 binary is written into the parameter **S-0-0170, Probing cycle procedure command**. The following will happen:

- The **data status** will be set to **7** by **S-0-0170, Probing cycle procedure command**, i.e., command in process.
- All probe values and probe value differences will be set to 0.
- All "probe ... latched“ parameters will be cancelled.
- The external voltage monitor will be activated (if it has not yet been activated).

## Signal Edge Selection for the Probe Inputs

A positive probe value and a negative probe value are available for every probe input. The positive probe value is assigned the 0→1 (rising) edge of the probe signal, and the negative probe value is assigned the 1→0 (falling) edge. The **S-0-0169, Probe control parameter** determines whether both occurring edges will be evaluated and will lead to the positive/negative probe values being saved.

Write into the parameter before activating the function. The structure looks liks this:

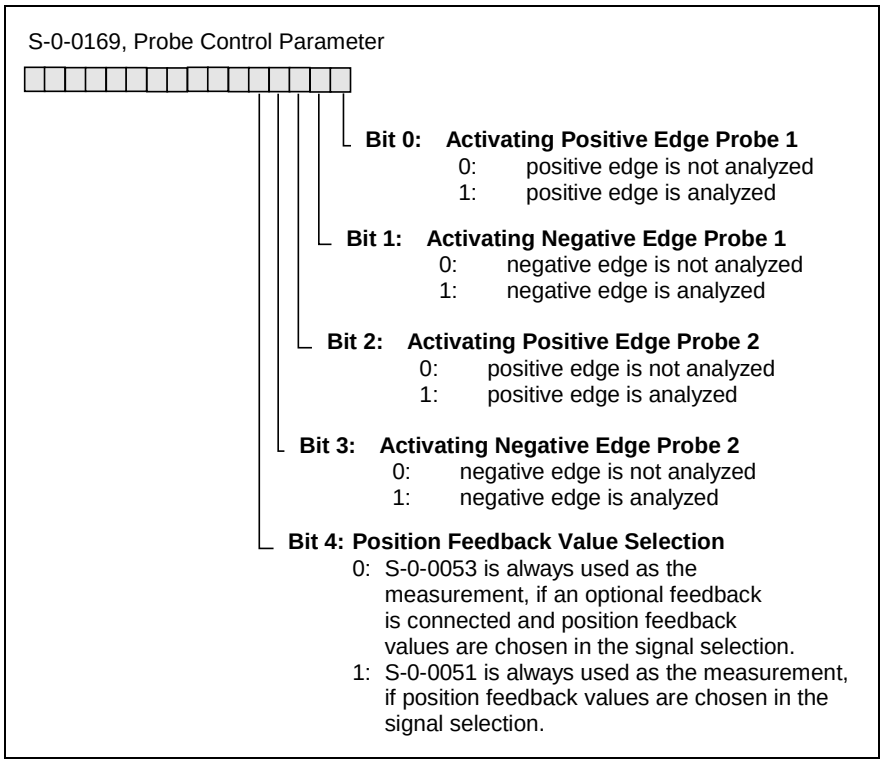

S-0-0169, Probe Control Parameter
Bit 0: Activating Positive Edge Probe 1
0: positive edge is not analyzed
1: positive edge is analyzed
Bit 1: Activating Negative Edge Probe 1
0: negative edge is not analyzed
1: negative edge is analyzed
Bit 2: Activating Positive Edge Probe 2
0: positive edge is not analyzed
1: positive edge is analyzed
Bit 3: Activating Negative Edge Probe 2
0: negative edge is not analyzed
1: negative edge is analyzed
Bit 4: Position Feedback Value Selection
0: S-0-0053 is always used as the measurement, if an optional feedback is connected and position feedback values are chosen in the signal selection.
1: S-0-0051 is always used as the measurement, if position feedback values are chosen in the signal selection.

Fig. 10-20: Structure of Parameter S-0-0169, Probe Control

## Signal Selection for the Probe Inputs

Values to be measured are:

- actual position value 1 (motor encoder)
- actual position value 2 (optional encoder, if mounted)
- internal time
- master axis position
- actual feedback value 3

The choice is made via parameters:

- **P-0-0200, Signal select probe 1** and
- **P-0-0201, Signal select probe 2**,

as well as in bit 4 of **S-0-0169, Probe control parameter**..

Using P-0-0200 or P-0-0201 it is possible to determine for both probe inputs whether an actual position value, an master axis position or an internal time is to be measured.

| Value of P-0-0200: | Signal: |
|---|---|
| 0 | actual position value 1/2 |
| 1 | time |
| 2 | master axis position |
| 3 | position feedback value 1 or 2 with monitoring window active |
| 4 | position feedback with monitoring window active |
| 5 | position feedback 3 |
| 6 | position feedback 3 with monitoring window active |

Fig. 10-21: Probe input function signal selection for probe 1

| Value of P-0-0201: | Signal: |
|---|---|
| 0 | actual position value 1/2 |
| 1 | time |
| 2 | master axis position |

Fig. 10-22: Probe input function signal selection for probe 2

Depending on this choice, the units, decimal places of parameter measured value positive and negative, Measured value difference, Start position probe function active and End position probe function active of the relevant probe are switched.

If the actual position value is selected in the signal select parameters (select = 0 or 3), then bit 4 in **S-0-0169, Probe control parameter** decides whether **S-0-0051, Position feedback 1 value** or **S-0-0053, Position feedback 2 value** will be used as signal.

It is optional for probe 1 to determine whether only master axis positions or actual position values are latched that are within a fixed range (signal select 3, 4 and 6). The range is defined with parameter **P-0-0204, Start position probe function active** and **P-0-0205, End position probe function active**.

### Connecting the Probe Inputs

See relevant project planning manual.

## 10.8 Positive stop drive procedure

The command **S-0-0149, d400 Positive stop drive procedure** turns off all controller monitors that would lead to an error message in Class 1 Diagnostics during the blocking of a drive during a fixed limit stop.

If the command is started, the drive generates the diagnostic message **D400 Positive stop drive procedure command**.

The controller monitors are switched off in all drive operating modes.

If there is a Class 1 Diagnostics error message at the start of the command, the error **D401 ZKL1-Error at command start** will be generated.

The drive will acknowledge the command as properly executed when:

- the controller monitors are switched off
- |Md| (S-0-0084) >= |$Md_{Limit}$| (S-0-0092) and
- $n_{feedback}$ = 0

**Note:** The message '$n_{feedback}$ = 0' is influenced by the parameter **S-0-0124, Standstill Window**.

If the command is cancelled by the control after execution, then all regular controller monitors are reactivated.

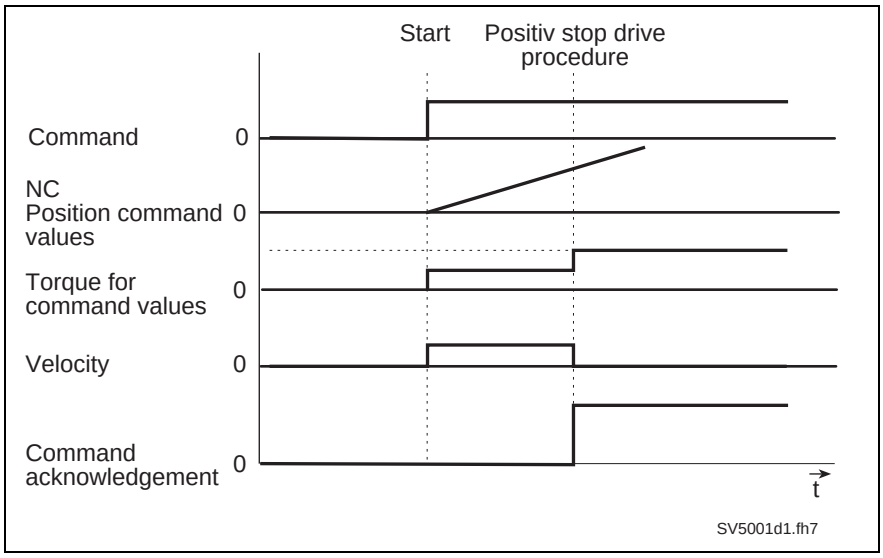



Fig. 10-23: Time sequence when activating the command: Positive stop drive procedure

# 10.9 Command - detect marker position

The command "Detect marker position" supports

- the control of a error free detection of the reference marker in an incremental measuring system or
- determining the position of the reference marker if the referencing procedure is conducted by the control. In this case, this information is used to switch the coordinate system in the control.

A reference switching evaluation is not run with this command.

The following parameters are provided for this function:

- **S-0-0173, Marker position A**
- **P-0-0014, D500 Command determine marker position**

## Functional principle of command detect marker position

Once the command **P-0-0014, D500 Command determine marker position** is activated, the following is done:

- The diagnosis **D500 detect marker position command** is generated.
- If an incremental measuring system is selected, then the detection of a reference marker is activated, and the drive waits for the next reference marker.
- If a reference marker is detected, i.e., the position of a reference marker has been runover, then its position feedback value is stored in parameter **S-0-0173, Marker position A.** This command is now signalled as completed.

**Note:** The drive generates no command values. The mode active at command start remains unchanged. To override the reference marker, the control must generate command values (e.g., by jogging), that cause a motion in the direction in which the reference markers are to be detected.

### Additional uses of parameter "S-0-0173, Marker position A

"In parameter **S-0-0173, Marker position A**, the position of the reference marker is also stored during the command **S-0-0148, C600 Drive controlled homing procedure command**. This relates, however, to the "old" coordinate system (before the coordinate system was switched while performing a homing function).

## 10.10 Command Parking Axis

The command "Parking Axis" supports the operational decoupling of an axis. This may, for example, be necessary if an axis is temporarily brought to a standstill. The start of the command switches off all monitoring functions of the measuring system and the control loops.

## Pertinent Parameters

- **S-0-0139, D700 Command parking axis**

## Functional principle

The command may only be started without drive enable.

If the command is activated with drive enable applied, then the drive generates command error **D701 Park axis only without drive enable.**

After starting command **S-0-0139, D700 Command Parking axis** it follows:

- that the measuring system monitors,
- the control loop monitors and
- the temperature monitors

are deactivated.

The measuring system initializations are conducted at the end of the command. This means all initializations as with command **S-0-0128, C200 Communication phase 4 transition check** are conducted. The display reads "**PA**".

This drive no longer accepts the drive enable.

# 10.11 Programmable Limit Switch

The "Programmable Limit Switch" feature allows for 16 PLS points. An individual on- and off-switch position and a delay time are available for each PLS point.

The reference signal can be either

**S-0-0051, Position feedback 1 value** or

**S-0-0053, Position feedback 2 value**.

The corresponding PLS bit can be inverted depending on how the on- and off-switch level is set.

**Note:** A switch cam is generated every 1 ms resulting in a total cycle time of 16 ms when parametrizing all 16 cams.

## Pertinent Parameters

- **P-0-0131, Signal Select Position Switch**
- **P-0-0132, Switch-On Treshold Position Switch**
- **P-0-0133, Switch Off-Treshold Position Switch**
- **P-0-0134, Position Switch Lead Time**
- **P-0-0135, Status Position Switch**

## Function diagram for the Programmable Limit Switch

This feature shows whether the selected reference signal lies within the range between the on- and off-switch position.

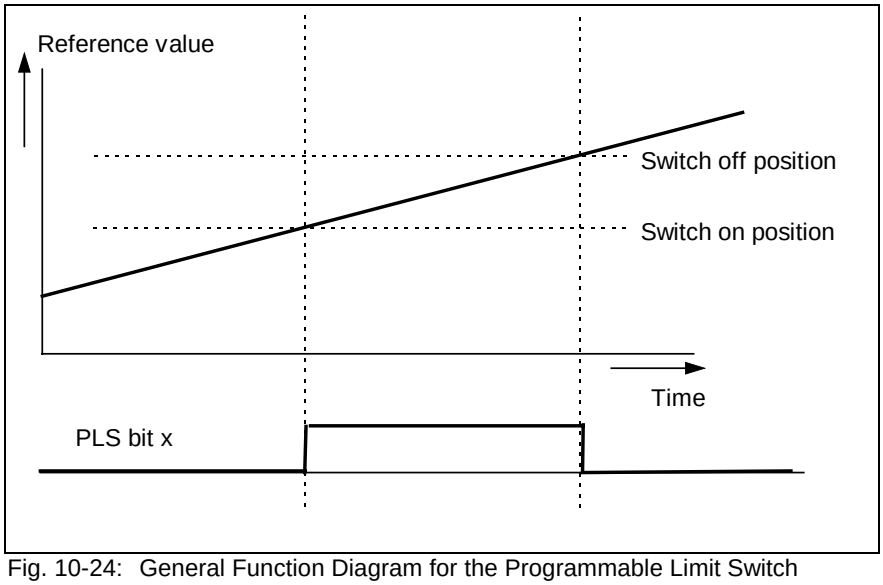



Fig. 10-24: General Function Diagram for the Programmable Limit Switch

The corresponding bit in the status position switch can be inverted by setting the on- and off-switch level.

There are two different situations that apply.

## Switch-on position smaller than the switch-off position

If the switch-on position is programmed smaller than the switch-off position, then the following applies:

The position switch is "1" if:

- Reference signal > Xon

AND

- Reference signal < Xoff

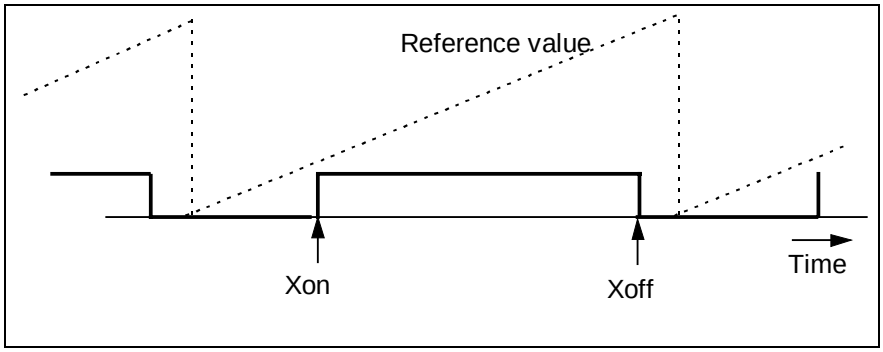



Fig. 10-25: Programmable Limit Switch with Xon < Xoff

## Switch-on Position larger than the switch-off Position

The programmable limit switch is "1" if the following applies:

- Reference signal > Xon

OR

- Reference signal < Xoff

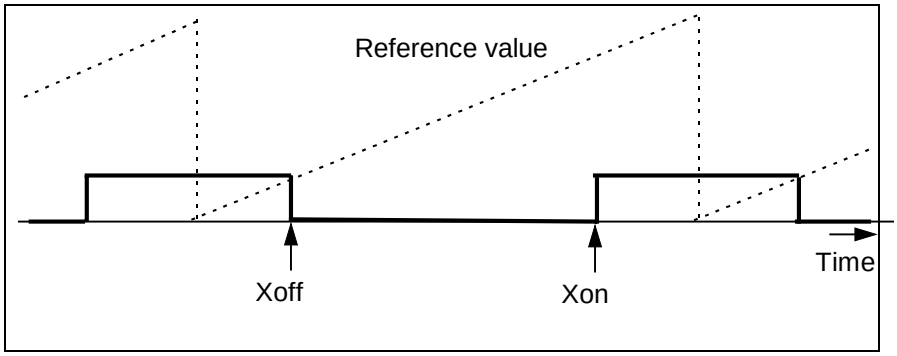



Fig. 10-26: Programmable Limit Switch With Xon > Xoff

A switch hysteresis is available to avoid position-switch flickering when the on- or off-switch level is reached.

## Programmable Limit Switch Lead Time

The velocity of the drive should remain constant while using the lead time.

By setting a lead time, compensation can be made for the delay of an external switch element that is controlled by a PLS bit. In that way, a theoretical adjustment value can be calculated from the lead time and the current drive velocity for the on- and off-switch positions. The PLS bit switches by the lead time before reaching the corresponding position.

The assumption is that velocity is constant in the range between the theoretical and real on- or off-switch position.

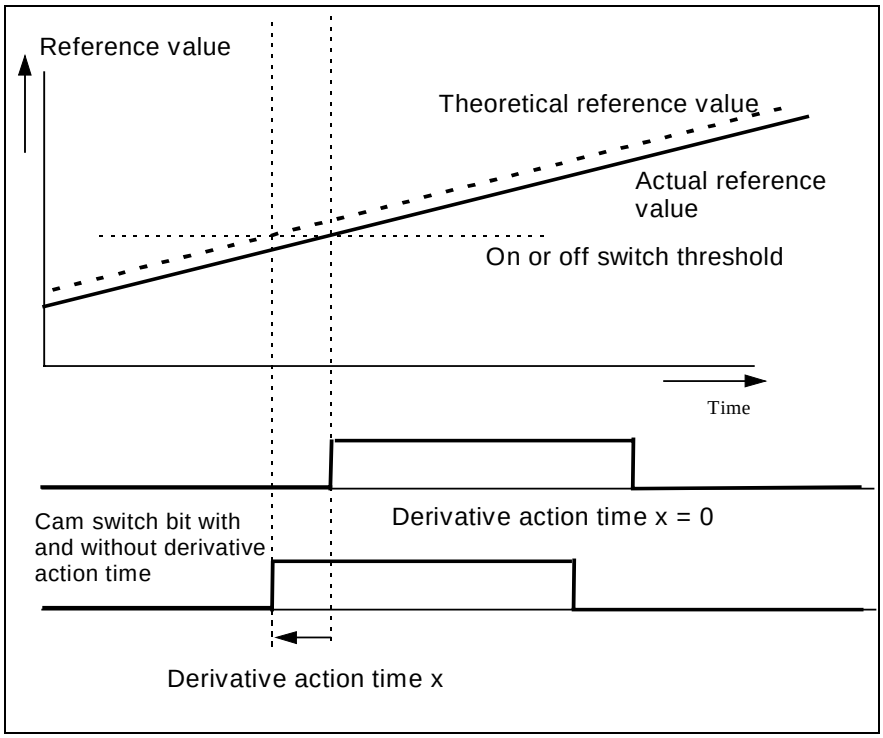

Reference value
Theoretical reference value
Actual reference value
On or off switch threshold
Time
Derivative action time x = 0
Cam switch bit with and without derivative action time
Derivative action time x

Fig. 10-27: Diagram for the Programmable Limit Switch Lead Time

## Parameterizing the Programmable Limit Switch

The **P-0-0131, Signal Selection for Programmable Limit Switch** parameter is used to activate the programmable limit switch and to select a signal. The following values can be entered:

| P-0-0131: | Feature: |
|---|---|
| 0 | The programmable limitswitch is not activated. |
| 1 | The programmable limit switch is activated; the reference signal is S-0-0051, Position feedback 1 value. |
| 2 | The programmable limit switch is activated; the reference signal is S-0-0053, Position feedback 2 value. |

Fig. 10-28: Programmable Limit Switch: Activation and Setting the Reference Signal

The **P-0-0134, Programmable Limit Switch Lead Time** parameter always should be parameterized completely (i.e., with all 16 elements), even if not using the delay.

The programmable limit switch parameters **P-0-0132, Switch-On position**, **P-0-0133, Switch-Off position** and **P-0-0134, Programmable Limit Switch Lead Time** can be used to set the on- and off-switch thresholds as well as the lead time.

Each of these parameters contains 16 elements. Element 1 is assigned for position switch bit 1, element 2 for bit 2, and so forth.

If one or more switch bits are not given a delay, then "0" should be set for these elements in **P-0-0134, Programmable Limit Switch Lead Time**.

The status of the position switch bits are shown in parameter **P-0-0135, Status Position Switch**.

# 10.12 Encoder Emulation

It is possible, with the help of encoder emulation to generate positions in the following standard formats

- **TTL format** with incremental encoder emulation
- **SSI format** with absolute encoder emulation.

This makes it possible to close the position control loop with an external control.

**Incremental encoder emulation**

Incremental encoder emulation is the reproduction of a real incremental encoder by a driver controller.

From the emulated incremental encoder signal, signals are relayed via a higher-ranking numeric control (NC) with information about the velocity of the motor mounted to the controller. By integrating this signal, the control generates information for itself about position. It is thus able to close a higher-ranking position control loop.

**Absolute encoder emulation**

"Absolute encoder emulation" means that the drive controller has the option of emulating a real absolute encoder in **SSI data format**. The drive controller thus offers the possibility of transmitting the position in SSI data format to the connected control (NC). Thus the control is able to close the position control loop.

## Pertinent Parameters

- **P-0-4020, Encoder emulation type**
- **P-0-0502, Encoder emulation, resolution**
- **P-0-0012, C300 Command 'Set absolute measurement'**

Parameter

- **P-0-0503, Marker pulse offset**

is used additionally for **incremental encoder emulation.**

Parameters

- **S-0-0076, Position data scaling type**
- **S-0-0052, Reference distance 1**
- **S-0-0051, Position feedback 1 value**
- **S-0-0053, Position feedback 2 value**
- **S-0-0047, Position command value**
- **P-0-0053, Master drive position**
- **P-0-0052, Position feedback value 3**
- **S-0-0121, Input revolutions of load gear**
- **S-0-0122, Output revolutions of load gear**
- **S-0-0123, Feed constant**

are used additionally for **absolute encoder emulation.**

## Activating Encoder Emulation

It is possible to control the behavior of the function with the help of parameter **P-0-4020, Encoder emulation type.**

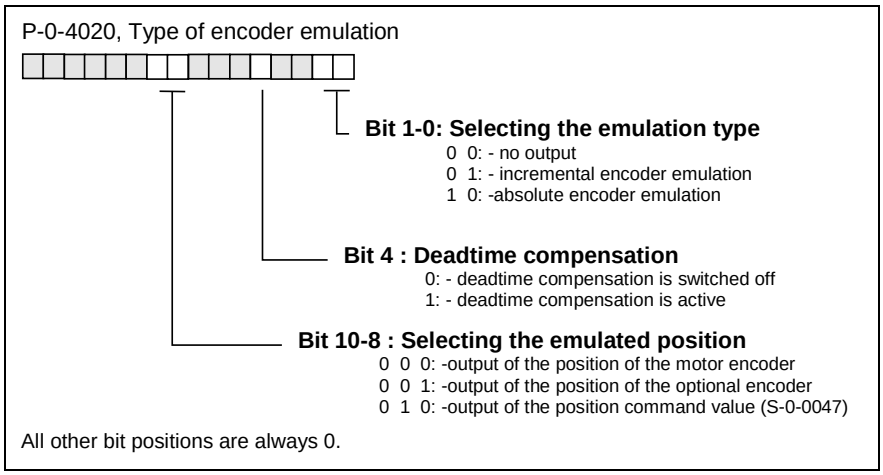

P-0-4020, Type of encoder emulation
Bit 1-0: Selecting the emulation type
0 0: - no output
0 1: - incremental encoder emulation
1 0: -absolute encoder emulation
Bit 4 : Deadtime compensation
0: - deadtime compensation is switched off
1: - deadtime compensation is active
Bit 10-8 : Selecting the emulated position
0 0 0: -output of the position of the motor encoder
0 0 1: -output of the position of the optional encoder
0 1 0: -output of the position command value (S-0-0047)
All other bit positions are always 0.

Fig. 10-29: Parameter encoder emulation type P-0-4020

## Functional principle: Incremental Encoder Emulation

**Number of lines**

The **number of lines** of the emulated incremental encoder is fixed in parameter **P-0-0502, Encoder emulation, resolution**:

- **1 to 65536 (=2^16) lines / revolution**

---

**Note:** If a motor with resolver feedback is mounted, then the emulator generates as many zero pulses per revolution as the resolver has pairs of poles. It must therefore be noted that the input for **P-0-0502**, **Encoder emulation, resolution** must be divisible by the number of resolver pole pairs without a remainder, otherwise the zero pulse will "run away".

---

**Unit**

The parameter unit depends on the motor type, i.e.,

- rotary motors: lines / revolution
- linear motors: lines / mm or lines / inch

### Position of the Zero Pulse as Relates to Motor Position

**Absolute encoder**

With motor encoders that achieve an absolute position within one motor revolution after initialization, or within one electrical revolution with resolvers, the zero pulse is always generated at the same motor position each time the unit is switched on.

**Non-absolute encoder**

Non-absolute encoders do not have an automatic method of determining position after powering up. This is why it is necessary to home. Homing uses the incremental encoder emulator zero pulse.

With non-absolute encoders, e.g., sine, gearwheel encoders, the following occurs automatically with each progression of phases 2 to 4 (in other words after each powering up of the drive controller):

- The detection of the motor encoder internal reference point is activated.
- The zero pulse output of the incremental encoder emulator is locked.
- The increment output is activated.

It is assumed that the motor can now be run via the position control loop by the control (homing, going to zero or referencing).

**Drive-guided referencing**

The drive can also conduct drive-guided referencing if the control permits it.

As soon as the motor encoder internal reference point is detected, the following is conducted:

- general release of zero pulse output
- immediate output of a zero pulse by the emulator
- initialization of zero pulse so that it is always output at this absolute motor position.

---

**Note:** The output of the zero pulse occurs after referencing is successfully completed. It is output at the same position, however, (reference marker).

---

**Zero pulse offset**

With **rotary motors** it is possible to offset the zero pulse using **P-0-0503**, **Marker pulse offset** within a (electrical or mechanical) rotation in a clockwise direction.

The **unit** of P-0-0503 is **degrees.** The input range for motor encoders that are absolute after their initialization with unequivocal positions within a **motor revolution** of **0..359.9999 degrees.**

The input range for resolvers with an absolute, unequivocal position within an **electrical revolution** is

**0 ... 359.9999 degrees /number of pole pairs.**

## Limiting Incremental Encoder Emulation

In contrast to the conventional incremental encoder with which the pulse output frequency is practically infinitely separated into very fine increments (i.e., the pulses are allocated to a fixed position), emulated incremental encoder signals are subject to certain restrictions. These are primarily the result of how the digital process of the drive controller works.

**Maximum output frequency**

The maximum pulse frequency for devices is 1024 kHz. If this frequency is exceeded, then pulses could be lost. The non-fatal error **F253 Incr. encoder emulator: pulse frequency too high** is generated. A position offset of the emulated position in contrast to the real position takes place.

$$l_{max} = \frac{f_{max} * 60}{n_{max}}$$

$l_{max}$: maximum line number
$n_{max}$: allowable maximum speed in 1/min

Fig. 10-30: Computing the maximum number of lines

**Compensation of delay (deadtime) between real and emulated positions**

Between position measurement and pulse output, there is a dead time (delay) of about 1ms in devices. If in parameter **P-0-4020, Encoder emulation type** bit 4 is set to 1, then this time is compensated in the drive.

**Pulse breaks at the end of the pulse output cycle**

At the end of each time interval the **signal level** for a specific period can **remain constant**. The output frequency may not be changed during the time interval of $T_A$. This is especially true of high frequencies, i.e., with a large number of lines and/or at high speeds.

# Diagnostic Messages with Incremental Encoder Emulation

The following diagnoses are generated with incremental encoder emulation:

- **F253 Incr. encoder emulator: pulse frequency too high**

**Cause:** The output frequency at the chosen number of lines exceeds the value of 1024 kHz.

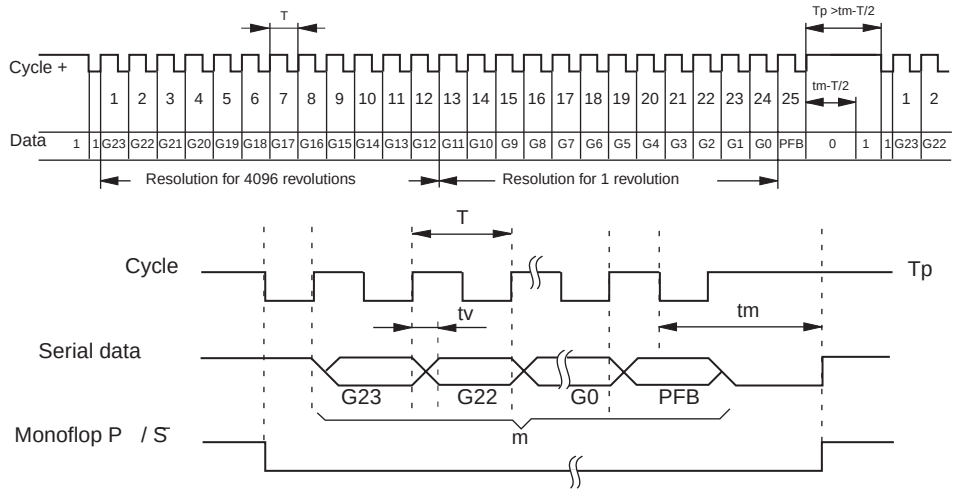
**Remedy:**

- Decrease input for **P-0-0502, Encoder emulation, resolution**
- Drop travel speed

# Functional Principle: Absolute Encoder Emulation

## SSI Format

The following illustrates the format of SSI data transmission.


T
Tp >tm-T/2
Cycle +
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
tm-T/2
1 2
Data
1 1 G23 G22 G21 G20 G19 G18 G17 G16 G15 G14 G13 G12 G11 G10 G9 G8 G7 G6 G5 G4 G3 G2 G1 G0 PFB 0 1 1 G23 G22
Resolution for 4096 revolutions
Resolution for 1 revolution
T
Cycle
Tp
tv
tm
Serial data
G23
G22
G0
PFB
Monoflop P / S
m

G0 = lowest value bit in the Gray-Code
G23 = highest value bit in the Gray-Code
m = saved parallel information
T = cycle signal period duration
tm = monoflop time 15µs to 25µs
Tp = cycle rest
tv = delay time for the first cycle max. 540ns, for all others max. 360ns
PFB = Power Failure Bit (is not used and is logically always... "0")

ap5002d1.fh7

Fig. 10-31: SSI format as pulse diagram

**Note:** The **Power Failure Bit** is not generated in the drive!

### Emulated position reference

The emulated signals "Actual position value encoder 1", "Actual position value encoder 2" and "Position command value" depends on **S-0-0076, Scaling type for position data** and is scaling dependent.

The values or emulator and parameter **S-0-0051, Actual position value encoder 1**, **S-0-0053, Actual position value encoder 2** or **S-0-0047, Position command value** run synchronously. This simplies emulation control, e.g., with the DriveTop program.

If **S-0-0076, Scaling type for position data** is used to parametrize motor reference, then an encoder-related emulation is possible.

If the data reference is load-related, then the feed constants and gear ratios must be entered application-specifically.

The values for actual position value 3 and master axis position are always encoder-related emulated. S-0-0076 has no meaning here.

## Resolution with Absolute Encoder Emulation

The output data format (number of bits/revolution) for the emulated SSI position is fixed in parameter **P-0-0502**, **Encoder emulation, resolution**.

The input range and unit depends on **S-0-0076, Position data scaling type.** The following combinations are possible:

- 10 .. 24 bit / revolution
- 4 .. 24 bit / mm
- 8 .. 24 bit / inch.

---

**Note:** The **unit** of the parameter is **switched** when selecting SSI emulation via parameter **P-0-4020, Encoder emulation type**.

---

## Referencing with Absolute Encoder Emulation

Using parameter **P-0-0012, C300 Command 'Set absolute measurement'** it is possible to reference the absolute position output by the absolute encoder emulator .

With set absolute dimension, the value of parameter S-0-0052 Reference distance 1 is set.

## Position jumps at the Display Limits of Absolute Encoder Emulation

Using SSI emulation, it is possible to illustrate 4096 revolutions absolutely. If when using SSI emulation the limit has been reached, then small position fluctuations lead to large **jumps in the emulated SSI position**.

This is the case with position 0 and 4096 revolutions.

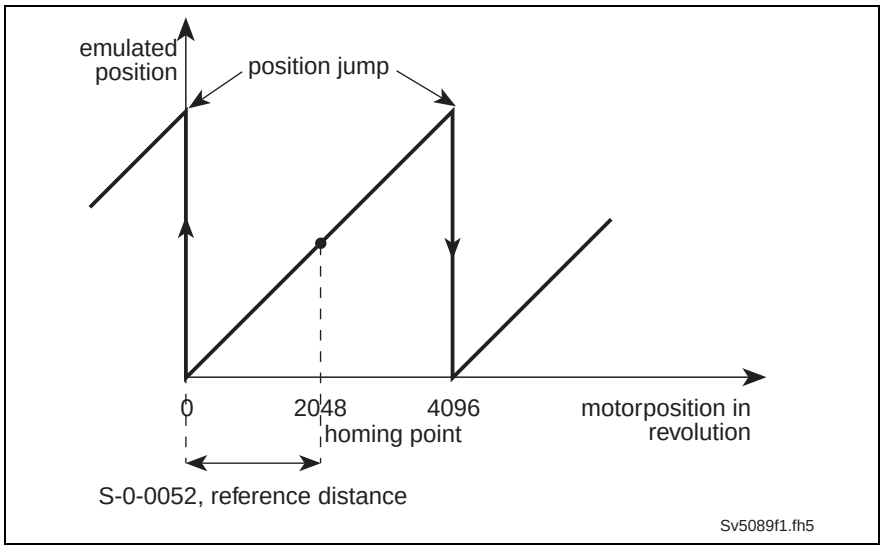



Fig. 10-32: SSI display limits

To avoid this, then use commando **P-0-0012, C300 Command 'Set absolute measurement'** to shift the SSI position value.

It is recommended to move the position into the centre of the SSI display range by means of the **S-0-0052, Reference distance 1**. This offers the option of running 2048 revolutions to the left and to the right.

## 10.13 Measuring wheel operation mode

The measuring wheel operation function is used, for example, in sheet-metal machining to feed the material into the machine. With the help of a measuring wheel encoder mounted to the material, a highly precise material machining is ensured even if some slip occurs between the driven motor and the material itself.

The measuring wheel encoder is only used if material is being machined. See the illustration below.

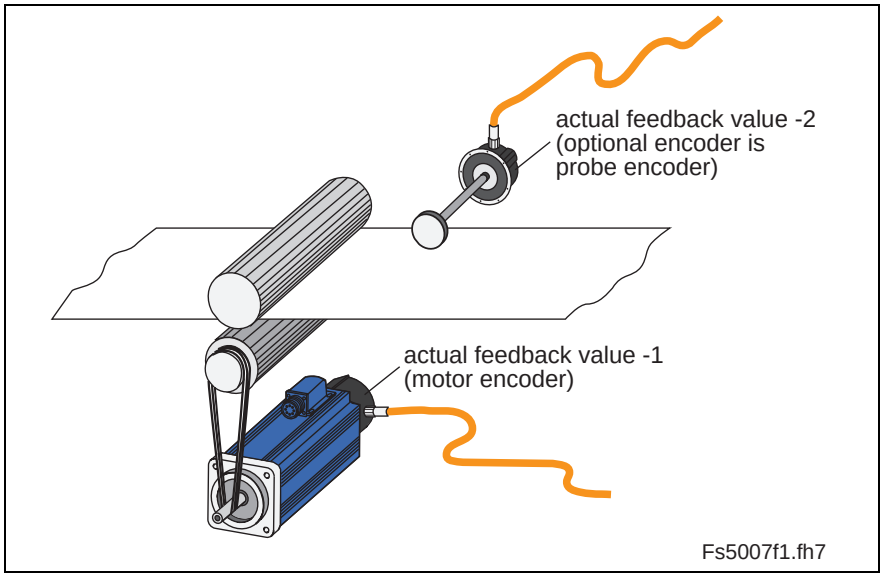



Fig. 10-33: A typical arrangement of drive with measuring wheel encoder

## Pertinent Parameters

The following parameters are used to parametrize this function:

- **P-0-0185, Function of encoder 2**
- **P-0-0220, D800 Command Measuring wheel operation mode**
- **P-0-0221, Actual position filter time constant for measuring wheel mode**

## The Functional Principle

The activation of the measuring wheel operation triggers a switching within the drive from control with encoder 1 (motor encoder) to hybrid position control (using the measuring wheel encoder).

The functional principle is illustrated below.

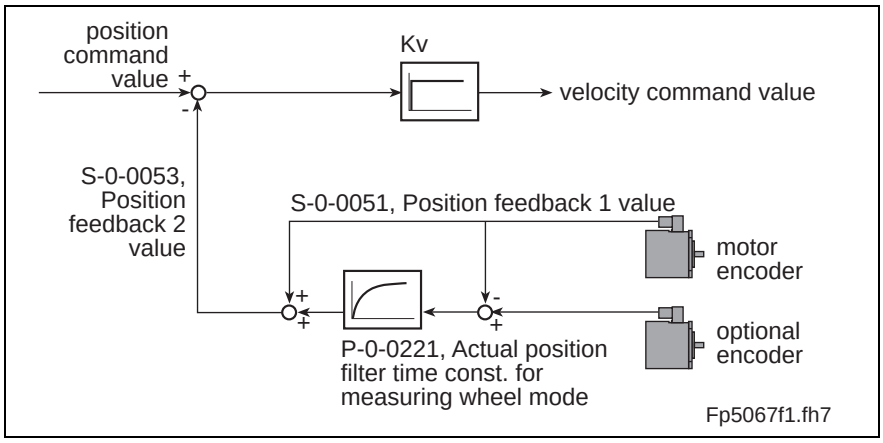



Fig. 10-34: Functional principle of the measuring wheel operation

Any negative effects caused by the poor coupling of encoder 2 to the motor shaft (due to material, perhaps) is to be subdued by attenuating the actual position value differences. The smoothing of this difference is set with the help of parameter **P-0-0221, Actual position filter time constant for measuring wheel mode**.

**Note:** If parameter **P-0-0221, Actual position filter time constant for measuring wheel mode** is parametrized with zero, then only the actual position value 2 of the optional encoder is used as actual position control value.

## Pre-Requisites

- The optional encoder must be registered as a measuring wheel encoder in parameter **P-0-0185, Function of encoder 2**.
- Material is in roll feed and under the measuring wheel.
- The roll feed is closed.
- The measuring wheel encoder is pressed up against the material.

**DANGER**

**Uncontrolled motions of the drive if measuring wheel encoder has no contact to material. The position control loop is open via encoder 2.**

⇒ The measuring wheel operation command may only be started if encoder 2 is actually in contact with the material.

## Activation

The function is activated with command **P-0-0220, D800 Command Measuring wheel operation mode**.

At the start of the command, the drive sets actual position value 2 (measuring wheel encoder) on actual position value 1.

The active operating mode determines further drive behavior.

**Drive in position control**

The drive switches into position control with encoders 1 **and** 2.

**Note:** The absolute position of the encoder is meaningless because the position is always re-initialized.

**Drive not in position control**

The position of the measuring wheel encoder is correctly detected. Control, however, uses encoder 1.

**Clearing the command**

Position control with the measuring wheel encoder remains active as long as the command is set.

When the command is cleared, the drive sets actual position value 1 on value 2 and then switches back to position control with encoder 1.

**Note:** Measuring encoder evaluation remains active even if:
- operating mode is switched during active command
- with an error
- with active drive halt
- or drive enable removed

### Parametrizing the Measuring Wheel Encoder

**Note:** When using a measuring wheel encoder, deactivate the monitoring window of encoder 2. Use parameter **S-0-0391, Monitoring window feedback 2** to do this.

A measuring wheel encoder is parametrized with parameters:

- **S-0-0123, Feed constant**
- **S-0-0115, Position feedback 2 type**
- **S-0-0117, Feedback 2 Resolution**

**Measuring wheel encoder parametrized as linear encoder**

If the path parametrized in parameter **S-0-0123, Feed constant** is not traversed during the course of one revolution, i.e., a revolution of the gear output does not equal a revolution of the measuring wheel, then the encoder must be parametrized as a linear encoder.

Enter encoder resolution as per the following formular:

$$encoder\ resolution = \frac{measuring\ wheel\ circumference}{(encoder\ cycle/revolution)}$$

Encoder resolution: **S-0-0117, Feedback 2 Resolution**

Fig. 10-35: Encoder resolution if measuring wheel encoder parametrized as linear encoder

In this case, linear encoder (bit 0 = 1) must be set in parameter **S-0-0115, Position feedback 2 type**.

## Diagnostic Messages

In conjunction with the command measuring wheel operation the following error messages could be generated:

- **D801 Measuring wheel operation not possible**

## Notes

# 11 Glossar

### Data status

Every parameter has at its disposal a data status. It can be read by the control via the required data channel. The information on the validity of the parameter or the command acknowledgement of the command are contained therein.

### Error reaction or response

If an error is detected in the drive, then the drive reacts independently by executing an error reaction. At the end of each error reaction there is a deactivation of the drive. The error reaction type is dependent on the error class of the error that occurred as well as the setting in parameters P-0-0117..119.

### E-Stop

E-Stop (Emergency Stop) is the determination for a hardware input at the drive controller. It is used to trigger the emergency stop function in the drive.

### External encoder

An external measuring system is optional. It is generally mounted directly to the load. The position feedback value of the encoder can be seen in S-0-0053, Position feedback 2 value. By activating the position control operating mode with encoder 2, the position control loop is closed with the help of the position feedback value of the external encoder.

### Ident Number

Every parameter is designated unambiguously by its ident number (IDN). It consists of these 3 components: S-SERCOS/P-Product specific, parameter set (0..7) and a number (1..4096).

### Load default or basic load

The control parameters are stored in the motor feedback data memory in both MDD and MKD motors. This makes it possible for the drive controller to work trouble-free with this motor. The control parameters have not been optimized for the application.

### Modulo format

Both position feedback and command values can be processed in modulo or absolute format. If modulo processing has been set, then the position data move within the range of 0..S-0-0103, modulo value. With this function, it is possible to realize an endlessly turning axis.

### Motor encoder

The motor encoder is the measuring system that is used during commutation. A measuring system is absolutely necessary. The position feedback value of the encoder can be seen in S-0-0051, position feedback value 1. By activating the position control operating mode with encoder 1, the position control loop is closed with the help of the position feedback of the motor encoder.

### Operating data

The operating data is data block element 7 of a parameter. The value of the parameter is stored there.

### Operating mode

Operating mode is set in parameters S-0-0032..35. It determines in what way a command value is processed in the drive and eventually initiates an axis movement. The operating mode does not define how the command value reaches the drive.

### Parameterization mode

The drive is in parameterization mode if communication phases 1..3 have been set. The drive cannot be activated (drive enable signal applied). Operating mode must first be switched into. Some parameters can only be written into during parameterization mode.

### Programming module

The programming module contains the software and parameter memory. It is mounted in slot U5. When exchanging the controller, a simple insertion of the programming module out of the old into the new unit means that the features of the replaced unit have been transferred to the new one.

### Home Switch

If during the command **S-0-0148, C600 Drive controlled homing** several reference marks can be reached within the travel range, it's the home switch which must specify one singular mark. The home switch is connected to the respective input at the drive and activated by bit 5 in S-0-0147, Homing Parameter. This input is mirrored in the parameter **S-0-0400, Home switch**.

### Scaling

The combination of unit and number of decimal places of a parameter are defined as scaling. It can be set for position, velocity and acceleration data.

### SERCOS interface

Digital interface for communication between control and drives in numerically controlled machines. One or multiple ring structures are implemented. The physical connection of the participants generally implements a fiber optic cable.

### Service Channel

The non-cyclic reading and writing of parameters via the SERCOS-Interface is done in the service channel

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ECODRIVE03
Drive For General
Automation With Fielbus-Interface

# Supplement A
# Serial Communication
# FGP 03VRS

DOK-ECODR3-FGP-03VRS**-FK02-EN-P

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# Notes

# 1 Serial Communication

## 1.1 An Overview

The drive controller is equipped with a serial interface. It supports the parametrization of the drive. Using this interface, it is possible to alter:

- **Parameters**
- **Commands and**
- **Diagnoses**

**Interface mode**

The interface can be operated in either

- **RS232 mode** or
- **RS485 mode**

**Interface protocol**

Two different protocols are supported:

- the Indramat **SIS protocol**
  The usable data are transmitted in INTEL format.
- **and an** ASCII protocol

Its precise structure is outlined in the following section.

---

**Note:** If an ASCII protocol is used, then the number of bytes differs from the data length in the parameter description (internal number format).

---

## 1.2 Pertinent Parameters

The data exchange which implements the serial interface is controlled by means of the following parameters:

- **P-0-4021, Baud rate RS-232/485**
- **P-0-4022, Drive address**
- **P-0-4050, Delay answer RS-232/485**

## 1.3 Function Principle

### Basic State once the Control Voltage is Switched On

After the control voltage is switched on, serial communications in the drive is in "**Passive mode**". Communications is not possible in passive mode.

**Selecting a Protocol**

To be able to take up serial communications with the drive it is necessary to set the communications mode (protocol)

- with a "**Change Drive" command** (with **ASCII protocol**)
- or a valid **Start telegram** (with **SIS protocol**).

---

**Note:** Internally, the first detected protocol that is valid (SIS or ASCII) is switched into. If a different protocol is to be used at some later point in time, then this is only possible by switching the 24 volt power supply off.

---

**Note:** The two listed options for establishing a connection, are extensively described in the section on

Communications procedures**.**

## Setting the Drive Address

The drive address is set via the serial interface by write accessing communications parameter **P-0-4022, Drive address.** DriveTop or a PLC can be used for this purpose.

Exception:

**If value** "**256**" is entered into communication parameter **P-0-4022,** then the unit address set via the address switch will be used for serial communications and not the value used in **P-0-4022.**

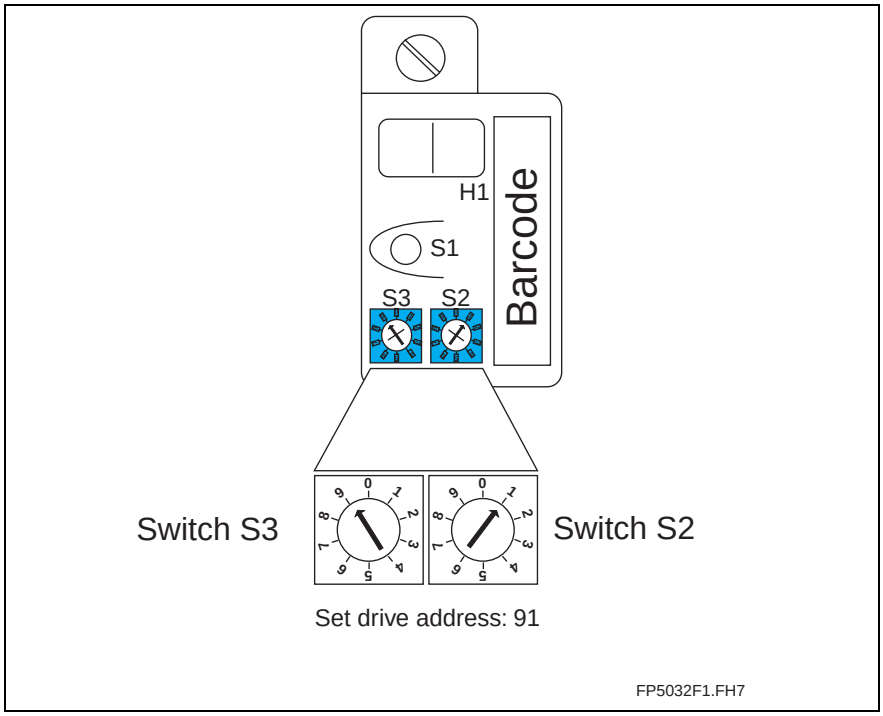


Fig. 1-1: Setting the address via the address switch on the programming module

**RS485 mode** It is only absolutely necessary to set the drive address if communications uses the RS485 bus because each bus participant will be addressed at a specific bus address.

**Note:** To avoid accessing conflicts, assign each drive address only once.

**RS232 mode** This mode does not necessitate the setting of drive address because only one participant is connected (peer-to-peer connection).

# Communications via RS232 Interface

## Features:

The RS232 interface is intended for use when connecting a PC with the **DriveTop** startup program.

- Transmission rate: 9600 and 19200 baud
- Maximum transmission path: 15m
- 8-bit **ASCII** protocol or 8-bit **SIS** protocol
- no parity bit
- a stop bit

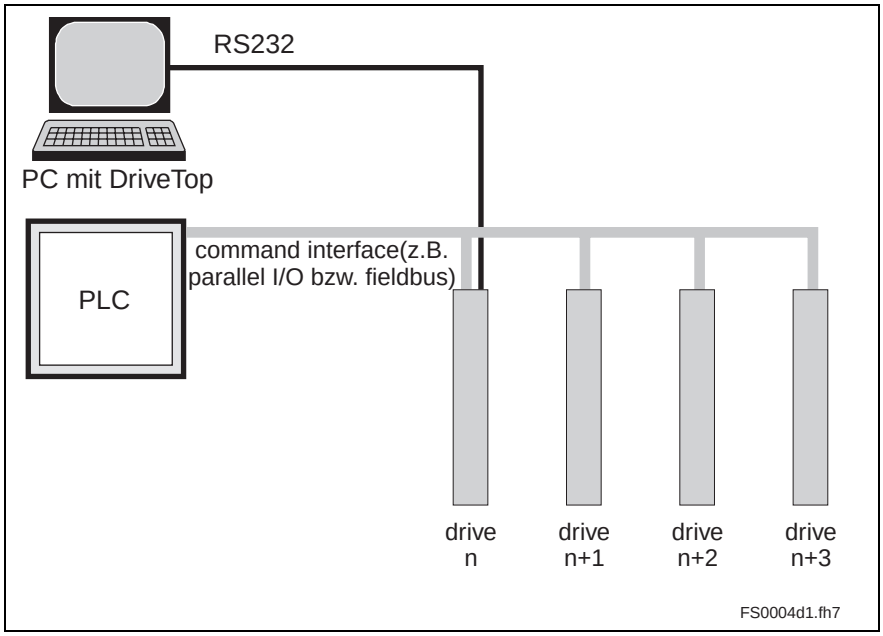


Fig. 1-2: Communications via RS 232 interface

# Communications via RS485 Interface

## Features

Communications via RS485 interface helps implement a **serial bus** with the following data:

- Up to **31 drives** can be connected to one bus master.
- Transmission rates of: **9600** and **19200** baud
- Maximum transmission path: **500m**
- **Half duplex** mode over a **2-wire** line
- 8-bit **ASCII** protocol or 8-bit **SIS** protocol
- no **parity bit**
- a stop bit

## Operating Several Drives with DriveTop

**Application advantages:**

- Starting up several drives without replugging an interface cable (central parametrization and diagnostics connection).
- Implementing a central PC-supported visualization unit.

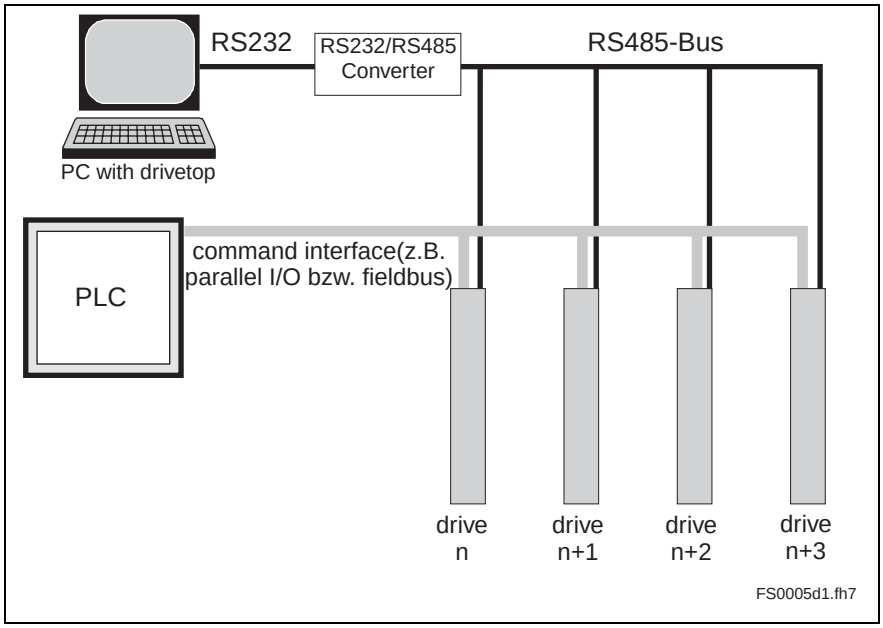


Fig. 1-3: Operating several drives with DriveTop

## Parametrization and Diagnosing with a PLC

**Application advantages:**

- Parameters can be changed with a PLC (e.g., adjuting positioning blocks).
- Expanded diagnostics options for the PLC by reading in error codes.

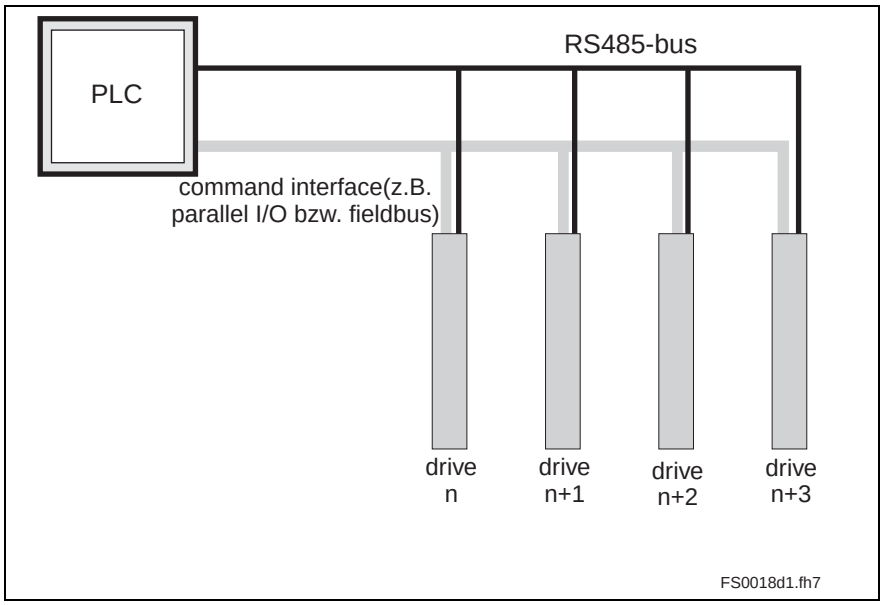


Fig. 1-4: Parametrizing and diagnosing with a PLC

### Parametrization and Diagnosing Drive Groups Using a Control Unit

**Application advantages:**

- Using a central visualization unit.

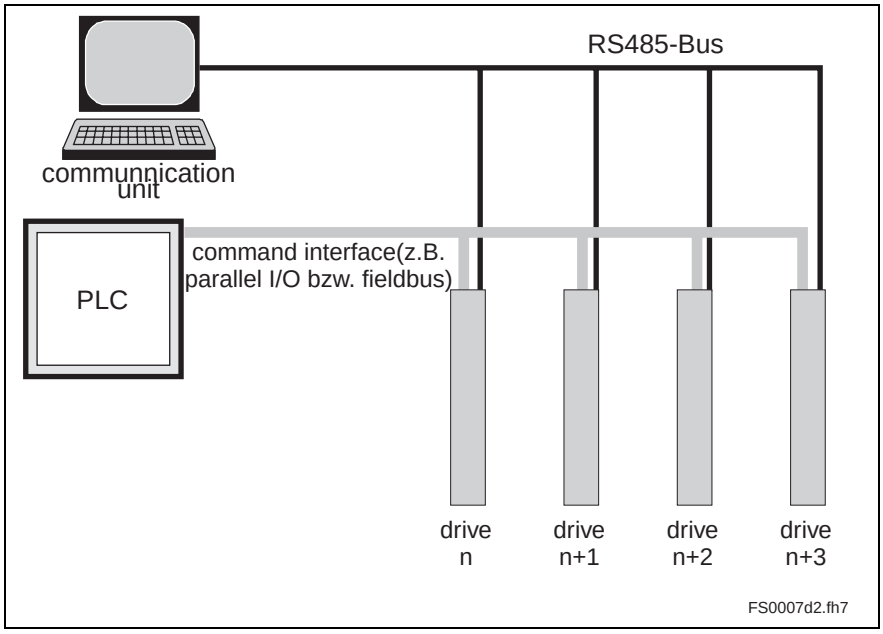


Fig. 1-5: Parametrization and diagnoses of drive groups using a control unit

## 1.4 Transmission Protocols

When switching on the 24V power voltage, an automatic protocol detection is activated upon receipt of a symbol from the serial interface.

As soon as either:

- a valid SIS start telegram
- or a valid ASCII start sequence ("bcd:address")

has been received, there is an internal switching to the relevant protocol and baud rate.

The drive supports two different protocols:

- ASCII protocol
- SIS protocol

These are explained below in greater detail.

# ASCII Protocol

**Features:**

- Transmission rates of: **9600** and **19200** baud
- Maximum transmission path: 1**5m**
- 8-bit **ASCII** protocol
- no **parity bit**
- a stop bit

## Structure, Telegram frame:

In this case, **no telegram frame** is used, but instead the transmitted ASCII symbol is converted and interpreted. It is only necessary to maintain a specified order.

# SIS protocol

## Features:

- This is a **binary protocol.**
- A checksum test is conducted (higher Hamming distance D).
- All telegrams are identified by an unequivocal start symbol.
- There is a defined telegram frame structure.
- It is possible to trigger movements via an SIS telegram (e.g., jogging).

## Structure, Telegram frame:

An SIS telegram is basically broken down into three blocks:

- Telegram head
- user data head
- user data head

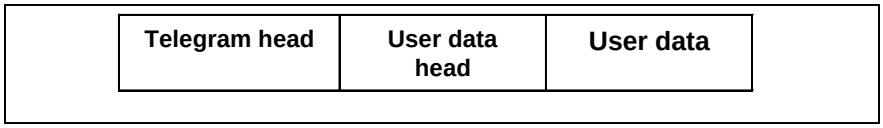


Fig. 1-6: The structure of an SIS telegram

## Telegram Head Structure

| Byte | name | Definition of the individual telegram bytes |
|---|---|---|
| 1 | StZ | Start symbol: STX (0x02) |
| 2 | CS | This is the checksum byte. It is generated by adding all subsequential telegram symbols as well as the start symbol StZ and concluding negation. In other words, the sum of all telgram symbols always equals 0 if the transmission was successful. |
| 3 | DatL | The length of the subsequential user data and the variable part are in the frame protocol. Up to **247 bytes** (255 - 7 {subaddresses} - 1 {running telegram number}) user data can be transmitted in one telegram. |
| 4 | DatLW | The repetition of DatL takes place here. The telegram length is generated from the DatLW and the fixed part of the frame protocol (byte 1 - 8), i.e., telegram length = DatLW + 8. |
| 5 | Cntrl | Bit 0 - 2: Number of subaddresses in the address block (0 - 7),<br>Bit 3: 'running telegram number' : 0 => not supported, 1 => additional byte<br>Bit 4: 0 => command telegram, 1 => reaction telegram<br>Bit 5 - 7: Status data for the reaction telegram:<br>000 no error, request was processed<br>001 transmission request being processed<br>010 transmission cannot presently be processed<br>100 warning<br>110 error |
| 6 | Service | This specifies the service that the sender is requesting of the receiver or which the receiver is conducting.<br>0x00 ... 0x0F general services<br>0x00 participant ID<br>0x01 terminate a data transmission<br>0x02 Flash operation<br>0x03 Initialization of SIS communication<br>0x0F Token Passing<br>0x10 ... 0x7F presently reserved<br>0x80 ... 0x8F special services for ECODRIVE<br>0x90 ... 0x9F special services for SYNAX<br>0xA0 ... 0xAF special services for MT-CNC or MTC200<br>0xB0 ... 0xBF special services for ISP200<br>0xC0 ... 0xCF special services for CLC-GPS<br>0xD0 ... 0xDF special services for HMI system<br>0xE0 ... 0xFF presently reserved |
| 7 | AdrS | Address of the sender: station number (0 - 127) |
| 8 | AdrE | Adress of the receiver:<br>AdrE = 0 - 127 ==> specifies a single station,<br>AdrE = 128 - 254 ==> addresses logical groups,<br>AdrE = 255 ==> fixes a broadcast<br>Telegrams with AdrE = 128 - 255 are **not** answered with a reaction telegram. |
| 9 | AdrES1 | Subaddress 1 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 000** |
| 10 | AdrES2 | Subaddress 2 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 001** |
| 11 | AdrES3 | Subaddress 3 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 010** |
| 12 | AdrES4 | Subaddress 4 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 011** |
| 13 | AdrES5 | Subaddress 5 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 100** |
| 14 | AdrES6 | Subaddress 6 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 101** |
| 15 | AdrES7 | Subaddress 7 of the receiver, **if for Bit 0 - 2 if for byte control it applies that: > 110** |
| 16 | PaketN | running telegram number (package number), **if bit 3 in byte cntrl has been set** |

Fig. 1-7: SIS-Telgram head

## Structure of the User Data Head

**Note:** The structure of the user data head depends on the transmission direction. Also the user data headers, described here are only used for the services 8x80…0x8F

It is differentiated between:

- **Command telegram** (Master --> Slave):

This is the telegram that the master sends to the slave (drive) !

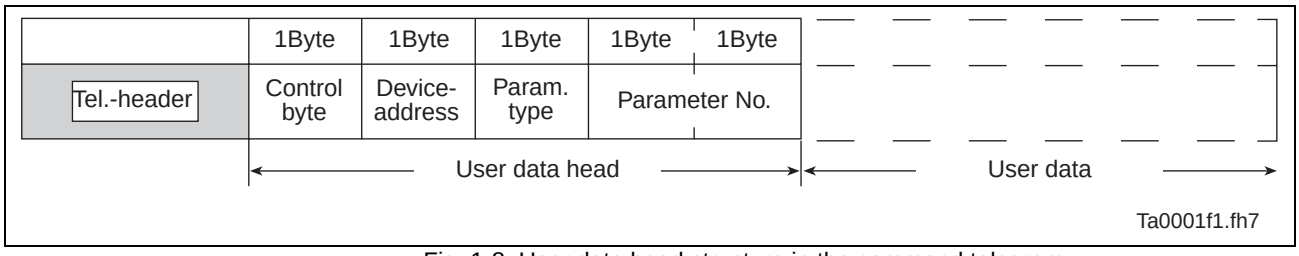


Fig. 1-8: User data head structure in the command telegram

- **Reaction telegram** (Slave--> Master):

This is the telegram that the slave sends to the master (Drive)!

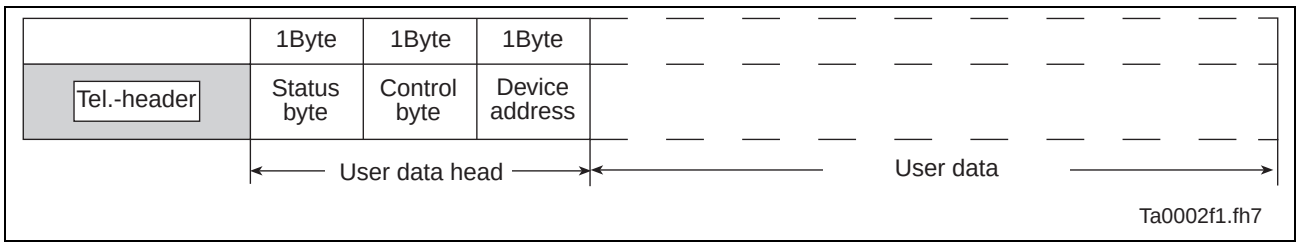


Fig. 1-9: User data head structure in reaction telegram

**The definition of the user data head** The user data head describes the mode of transmission in the command telegram.

**Control byte** The data block element of a parameter which is being accessed is described in the control byte. Bit 2 is used to control the transmission of following telegrams (the writing of lists in several increments).

**Unit address** The unit address set at the address switch must be entered here.

**Parameter Number and Type** The parameter number has the format set in the SERCOS interface specification. To be able to address control parameters as well, 1 byte is set in front of the address to identify the parameter type.

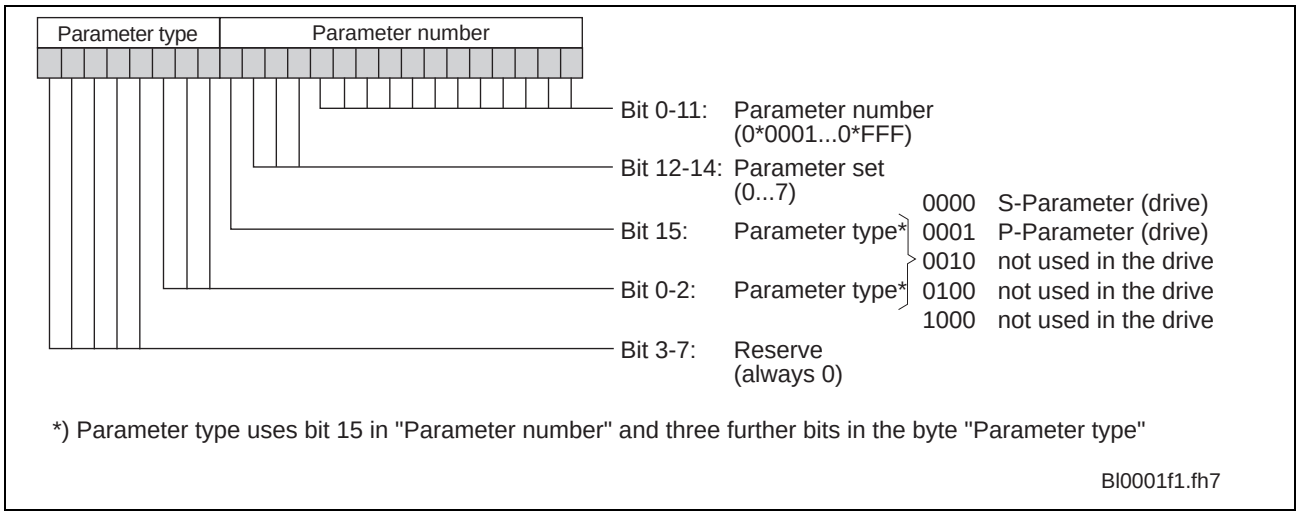
Parameter type
Parameter number
Bit 0-11: Parameter number (0*0001...0*FFF)
Bit 12-14: Parameter set (0...7)
Bit 15: Parameter type*
Bit 0-2: Parameter type*
Bit 3-7: Reserve (always 0)
0000 S-Parameter (drive)
0001 P-Parameter (drive)
0010 not used in the drive
0100 not used in the drive
1000 not used in the drive
*) Parameter type uses bit 15 in "Parameter number" and three further bits in the byte "Parameter type"
Bl0001f1.fh7

Fig. 1-10: Parameter number and type in user data head

### Structure of the User Data Field

Values of any kind can be entered in the user data byte. These cans can be interpreted as needed by a specific service. For example, binary symbols are entered into the user data during flash programming and the decimal value when writing a parameter. The length of the user data field is set with both the DatL and DatLW bytes in the telegram head.

## 1.5 Communications procedures

## General Information on the Parameter Structure

All parameters of the drive controller are stored in a uniform parameter structure. Each parameter is made up of 7 elements. The table below describes the individual elements and access possibilities. The parameter structures illustrated here will be referenced in the following sections.

| Element no. | Data block element | Access posibilities |
|---|---|---|
| 1 | ID number | read |
| 2 | name | read |
| 3 | attribute | read |
| 4 | unit | read |
| 5 | min. input value | read |
| 6 | max. input value | read |
| 7 | operating data | read / write |

Fig. 1-11: Parameter structure

**Note:** Attached is a parameter description with detailed data of the features of all available parameters.

# Communicating with an ASCII Protocol

## Actuating a Specific Bus User

To communicate with a bus user then it must be directly addressed with a CHANGE DRIVE command, specifying the drive address. With each CD command, the drive specified by the address is activ. All other ddrives are switched into passive mode. The addressed drive signals with a prompt. As of this point, all further communication takes place with this drive until another CHANGE DRIVE command switches to another drive.

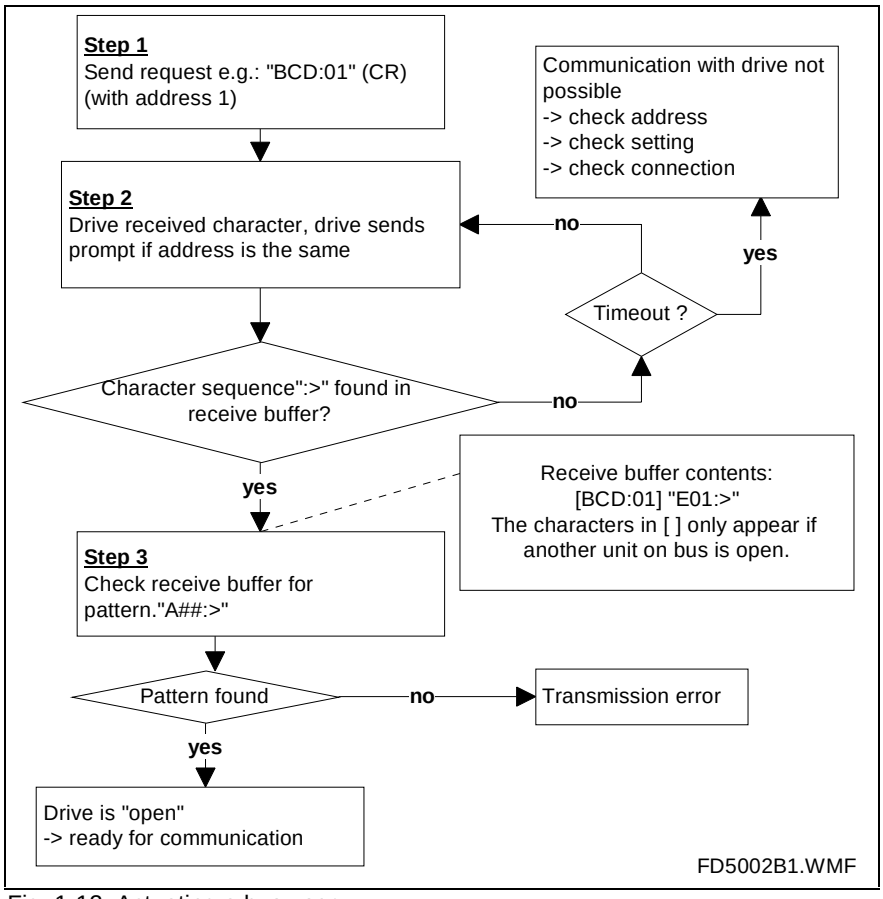


Fig. 1-12: Actuating a bus user

**Write Accessing a Parameter**

The write accessing of a parameter generally takes place as follows:

***ID number of parameter, data block element number, with operating data (Carriage Return)***

Once a write operation is completed, the drive signals with a prompt.

To access the parameter value of parameter P-0-4037, for example, the following must be input:

**Note:** All data entered must correspond to the data type set in the attribute (HEX, BIN, DEZ).

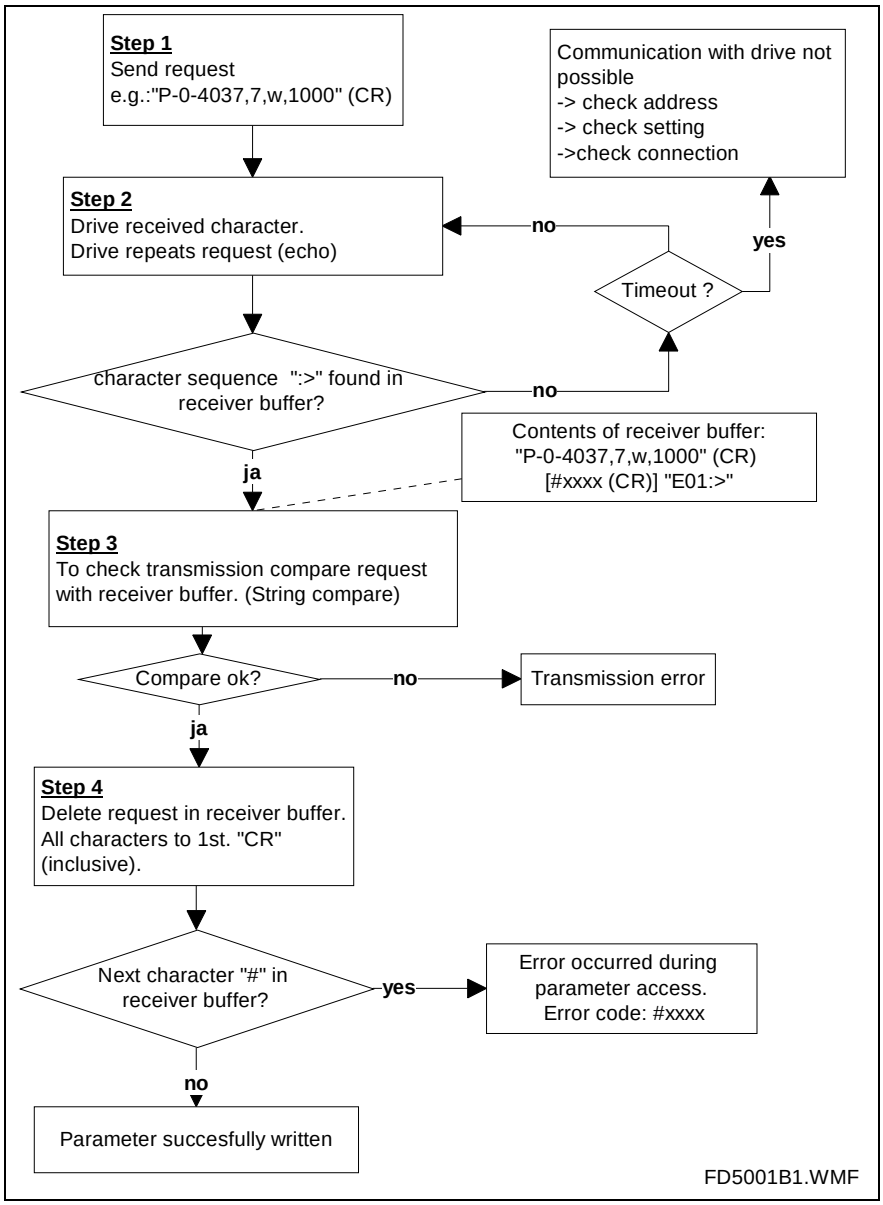


Fig. 1-13: Write accessing a parameter

Also see "Error Messages"

## Read Accessing a Parameter

Read accessing a parameter looks like this :

***ID number of parameter, data block element number (Carriage Return)***

The drive plays back the contents of the addressed data block element.

To access the operating data of parameter P-0-4040, for example, the following must be input:

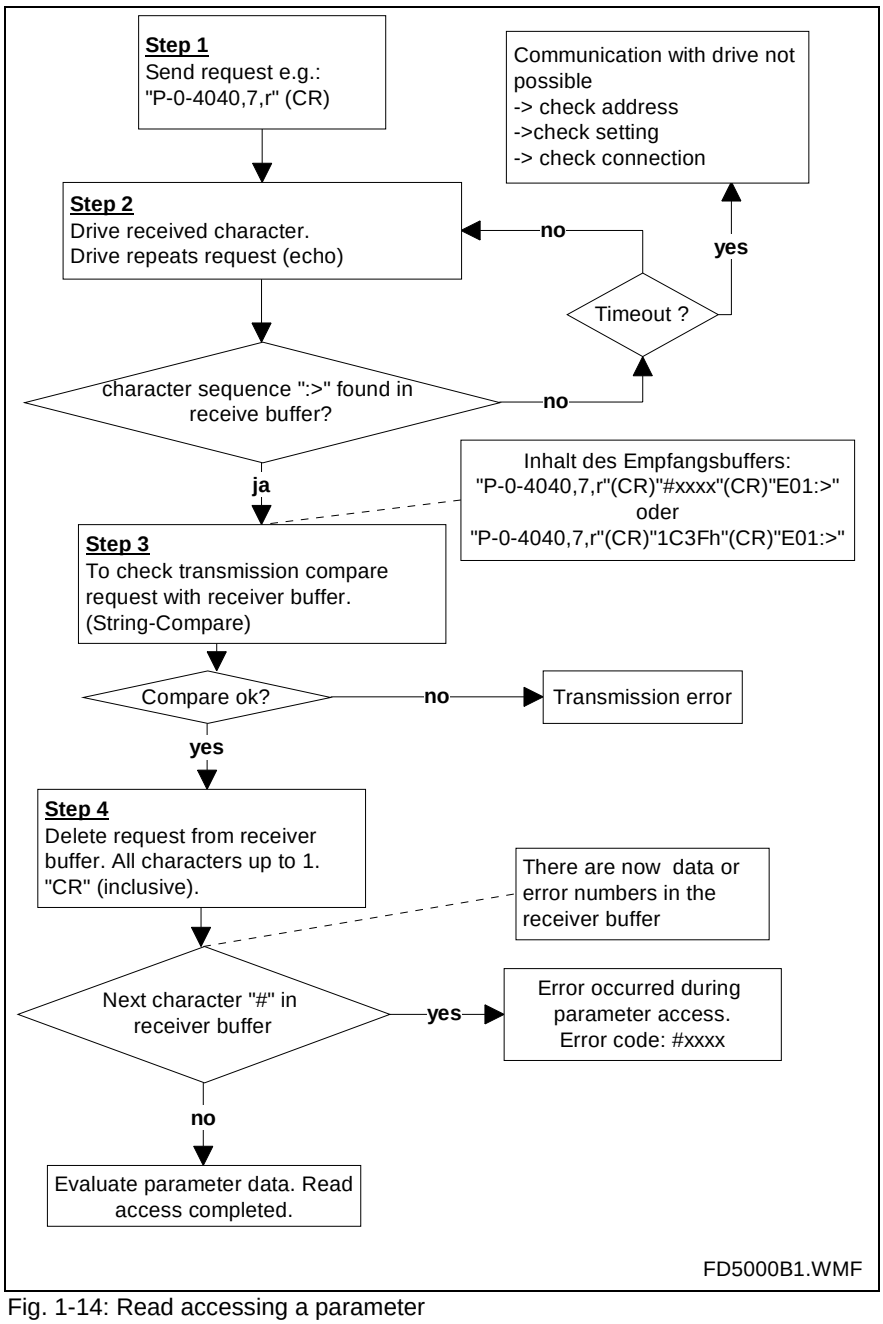


Fig. 1-14: Read accessing a parameter

## Write Accessing List Parameters

There are a number of lists in the drive. These can be addressed when writing in a modified way.

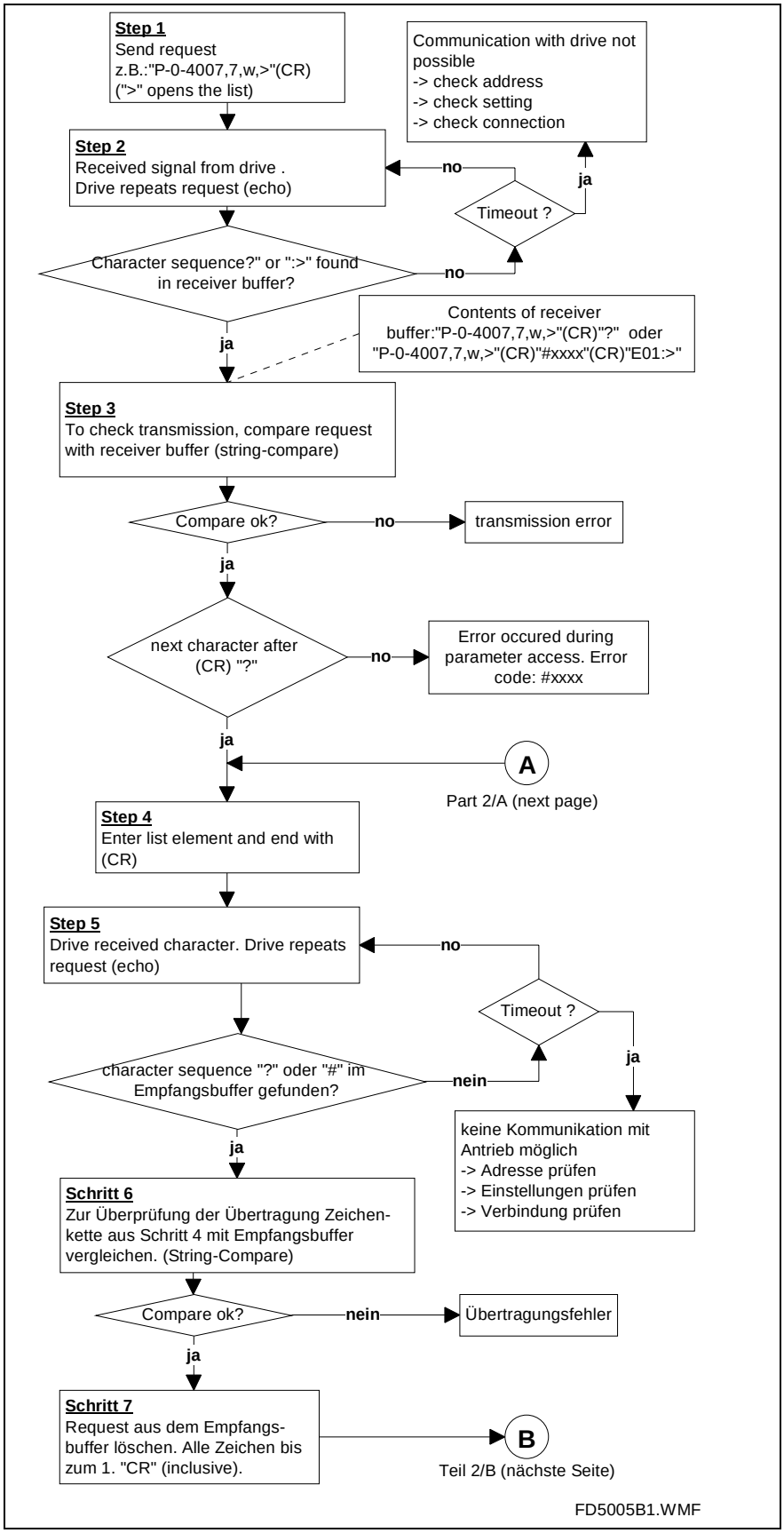


Fig. 1-15: Write accessing list parameters (part 1)

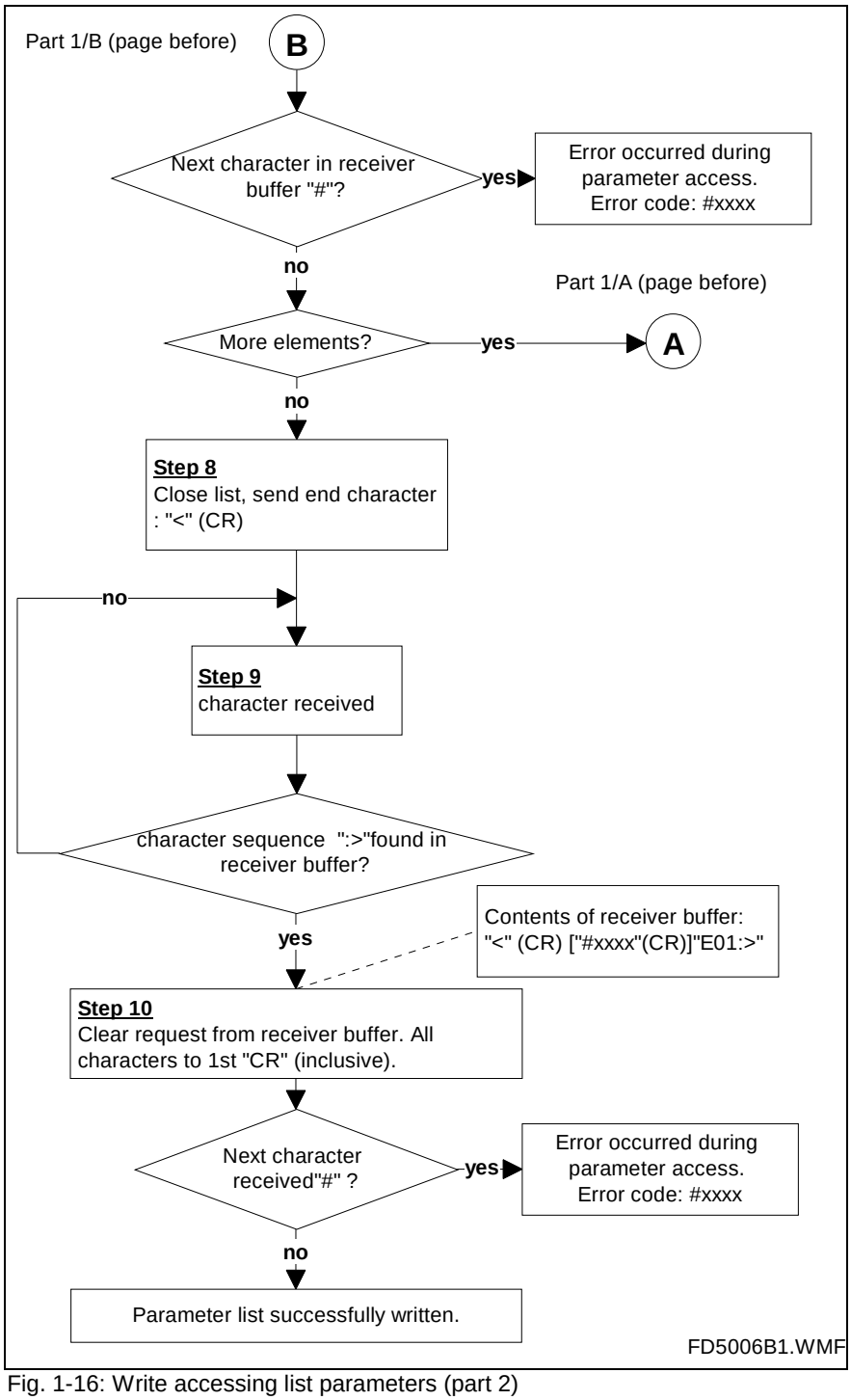


Fig. 1-16: Write accessing list parameters (part 2)

It is important to conclude the input with a "<" symbol as only then will be the data be assumed in the drive.

## Reading Accessing List Parameters

List parameters are read accessed in the same way as normal parameters. The drive supplies a list element as response, however.

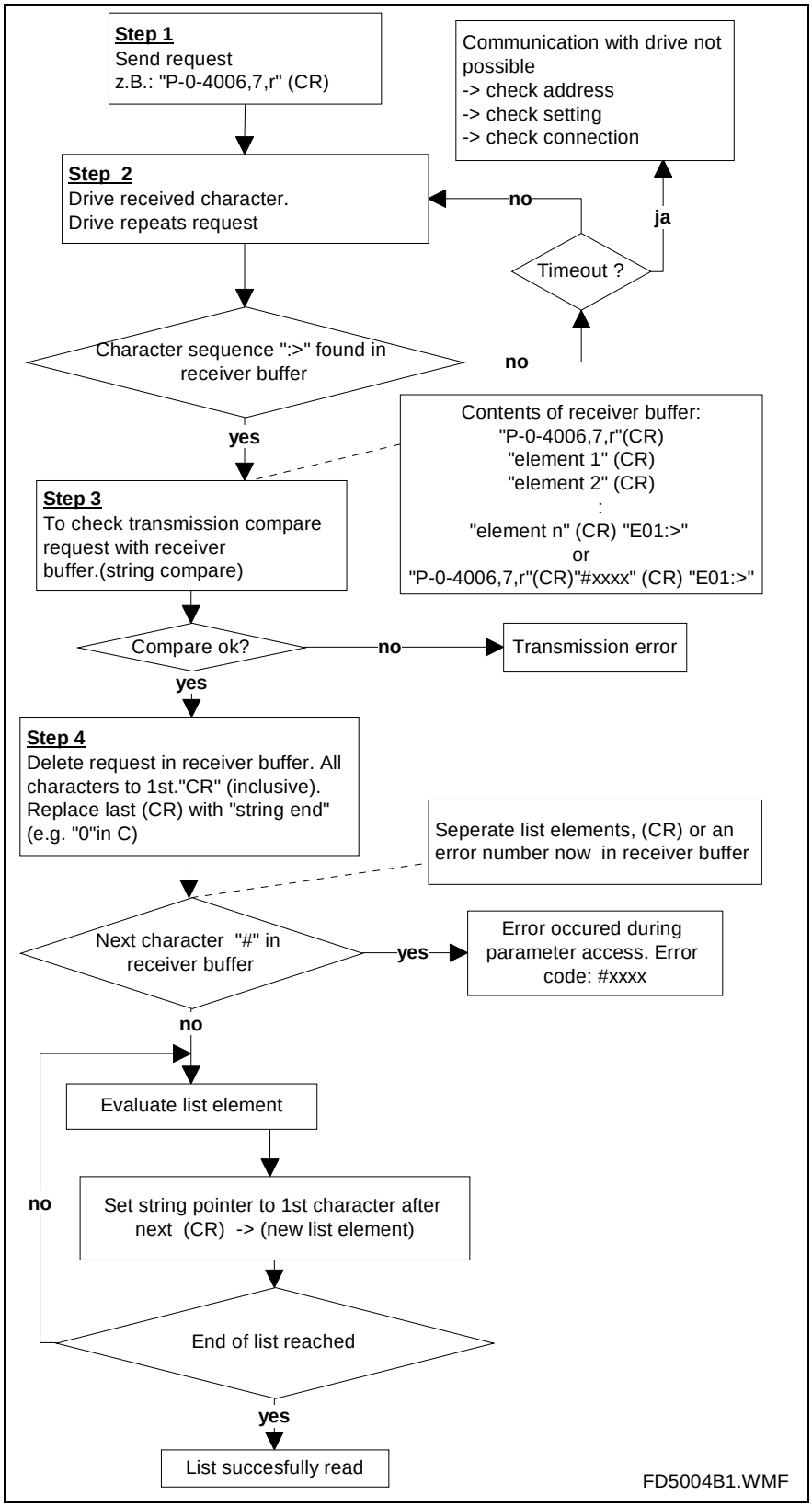


Fig. 1-17: Read accessing list parameters

## Starting a Command

Numerous commands can be conducted in the drive controller . Command execution takes place automatically in the drive.

There are commands for:

- **Switching between operating and parametrization modes: S-0-0127, C100 Communication phase 3 transition check S-0-0128, C200 Communication phase 4 transition check P-0-4023, C400 Communication phase 2 transition**
- **S-0-0262, C700 Command basic load**
- **S-0-0099, C500 Reset class 1 diagnostic**
- **S-0-0148, C600 Drive controlled homing procedure command**
- **P-0-0012, C300 Command 'Set absolute measurement'**

A command can be started, terminated and completed via the serial interface. The status of command execution can also be read.

A command is started as follows:

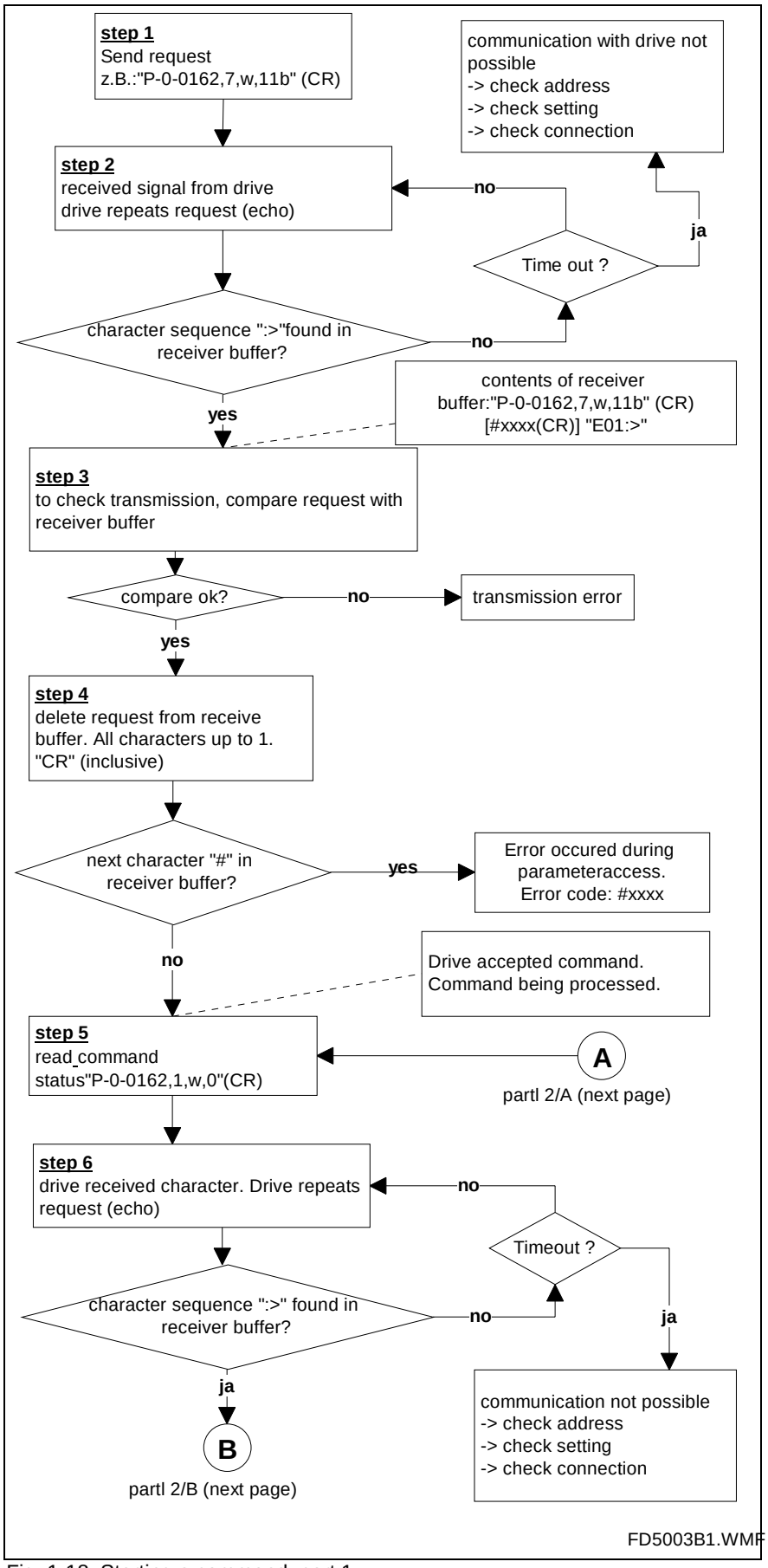


Fig. 1-18: Starting a command, part 1

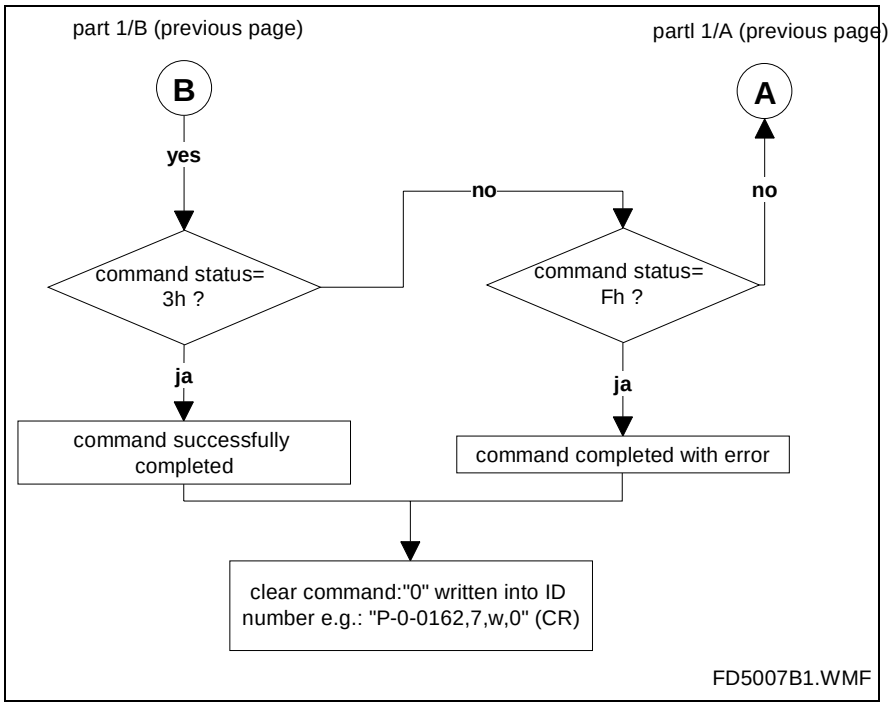


Fig. 1-19: Starting a command, part 2

## Querying Command Status

The current status of a command can be queried. By doing so, it can be ascertained that the drive has concluded command execution before the control (or PC) has ended the command.

The command status is queried as follows:

***ID number of command,1,w,0 (Carriage Return)***

The drive signals the current command status after the ID number of the command parameter is written.

**Possible status messages:**

| | |
|---|---|
| 0 h | command not set in drive |
| 1 h | command set in drive |
| 3 h | command set, released and properly executed |
| 5 h | command set in drive and enabled |
| 7 h | command set and enabled, but not executed |
| F h | command set and enabled, but not executed, as error present |

Fig. 1-20: Status messages

The command status is transmitted in bit list form. The definition of the individual bits is illustrated below.

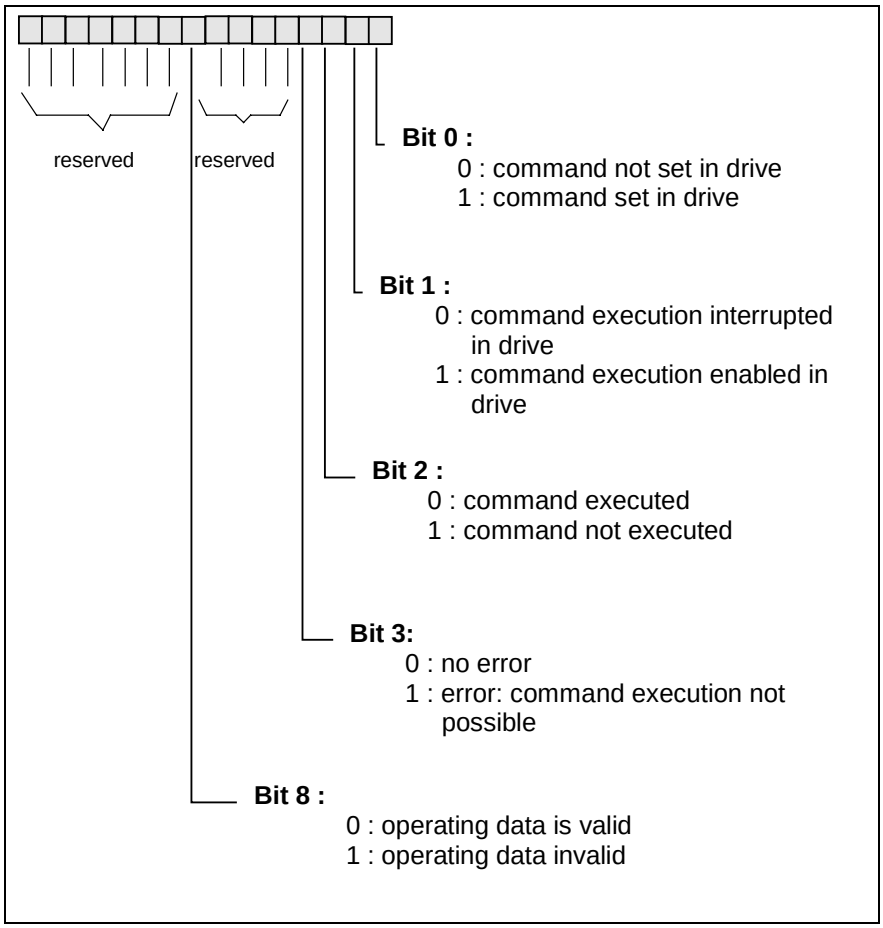
reserved
reserved
Bit 0 :
0 : command not set in drive
1 : command set in drive
Bit 1 :
0 : command execution interrupted in drive
1 : command execution enabled in drive
Bit 2 :
0 : command executed
1 : command not executed
Bit 3:
0 : no error
1 : error: command execution not possible
Bit 8 :
0 : operating data is valid
1 : operating data invalid

Fig. 1-21: Command acknowledgement (data status)

## Ending a command

A command is ended as follows:

***ID number of command,7,w,0 (Carriage Return)***

# Communicating with the SIS protocol

## Actuating a Drive via an SIS protocol

When communicating with SISprotocols, a difference is made between **comand telegram** and **reaction telegramm** depending on transmission direction. A user can only be addressed if a specific telegram format (frame) is maintained at his address (see programming module).

**Note:** Only after the drive has received at least a valid SIS telegram is the SIS channel free for further communications.

The individual **access modes** are described briefly below before the individual **services** are explained.

**General information about read accessing**

If a command telegram is used to start a read of a parameter, then the drive checks whether a **following telegram is needed.** In this case, the reaction telegram in the control byte is retained in

**Bit 2** (running / final transmission) at "**0“** until the final reaction telegram is sent. Bit 2 is set to 1 herein.

The transmission of a following reaction telegram is triggered by the renewed transmission of an unchanged command telegram.

**General information for following telegram accessing**

If write or read of a parameter is started in the drive with a following telegram, then this must be concluded of terminated before a different service can be started. If a different service was started anyway, then error code **0x800C "unallowed access**“ is sent in the reaction telegram. The previously started service with following telegrams can then be processed as usual in the next command telegram, or terminated.

A difference is made between

- **general** and
- **special services**.

## Service 0x01 Terminating a Data Transmission

**Command telegram**

- Enter 0x01 in the service of the telegram head.
- Enter the terminated service in the user head.

**Reaction telegram**

If there is **no error,** then the reaction telegram has the following structure:

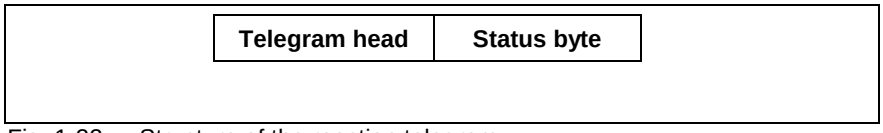


Fig. 1-22: Structure of the reaction telegram

If there is an **error,** then user data containing the error codes are sent. The user data head corresponds to the SIS specificaiton.

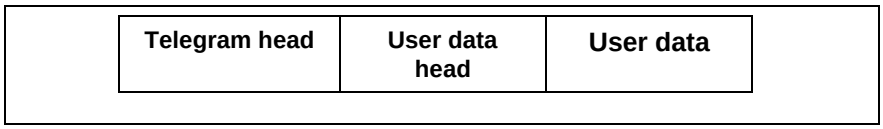


Fig. 1-23: Structure of the reaction telegram

**Note:** If no following telegrams are processed but this service is sent anyway, then no error reaction telegram will be sent!

## Service 0x0F Token Passing

**Note:** This service is not suppported in ECODRIVE!

**Reaction telegram**

Error code 0x0F "**Invalid service**" is sent in the status byte of the des **user data**.

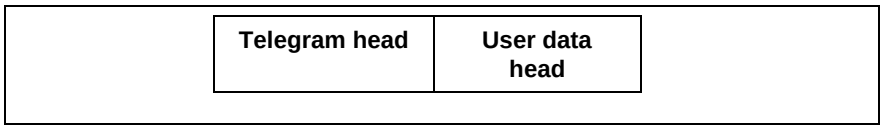


Fig. 1-24: Structure des Reaction telegrams

## Service 0x80 read a parameter

**Command telegram**

- Enter **0x80** in the service of the telegram head.
- Enter the parameter to be read in bytes **Parameter type** and **Parameter no**. of the user data head.
- Do not enter **user data bytes**.

**Reaction telegram**

- Using bit 2 the running / final transmission is designated in the control byte of the reaction telegram.

## Service 0x81 Read a List Segment

**Command telegram**

- Enter **0x81** in the service of the telegram head.
- Parameter type and parameter no. of the parameter to be read must be entered in the user data head.
- in the user data bytes 0 and 1 of the **offset** within the list as word =16 Bit
- in user data bytes 2 and 3 the **number** of the **words** to be read

**Reaction telegram**

- Bit 2 identifies the running / final transmission in the control byte of the reaction telegram.

**Note:** The output of a following telegram is started by a renewed transmission of the unchanged command telegram.

## Service 0x8E write a list segment

**Command telegram**

- Enter **0x8E** in the service of the telegram head.
- Enter parameter type and number of the parameter to be read in the user data head.
- in user data bytes 0 and 1 of the **offset** within the list as word =16 Bit
- in user data bytes 2 and 3 the **number** of the **words** to be written

**Reaction telegram**

- Any occurring errors are entered in the user data of the reaction telegram.

**Note:** Only list segments can be processed with this service that are contained in the present list. If the actual list length is to be changed, then this change must be specified. It is not possible to operate in following telegram mode.

## Service 0x8F write a parameter

**Command telegram**

- Enter 0x8F in the service of the telegram head.
- Enter the parameter to be written into into in parameter type and number bytes of the user data head.
- Enter the value to be written into the user data head.

**Reaction telegram**

**Note:** This service can be used to start all commands in the drive.

## Starting a command

Via the SIS interface all commands in the drive can be started with Service **0x8F "write a parameter“**.

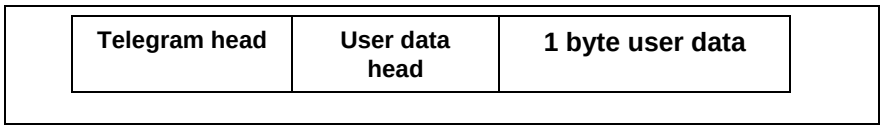


Fig. 1-25: Structure of the command telegram

- Enter 0x8F in the service of the telegram head.
- Enter the actuating command in parameter type and number bytes of the user data head.
- Enter the default of the command in the user data head.

## Possible commands in the drive

| Command | Drive parameter | Parameter no. in telegram |
|---|---|---|
| Drive-guided referencing | S-0-0148 | 0x0094 |
| Reset C1D | S-0-0099 | 0x0063 |
| Communications phase 3 transition check | S-0-0127 | 0x007F |
| Communications phase 4 transition check | S-0-0128 | 0x0080 |
| Base load | S-0-0262 | 0x0106 |
| Set absolute measurement | P-0-0012 | 0x800C |
| Load base parameters | P-0-4094 | 0x8FFE |
| Communications phase 2 transition check | P-0-4023 | 0x8FB7 |
| Set absolute dimension emulator | P-0-4032 | 0x8FC0 |
| Automatic control loop settings | P-0-0162 | 0x80A2 |

Fig. 1-26: Commands in drive

Always set parameter type to 0x00. Thus only S and P parameters are possible.

| Default in user data byte | Effects |
|---|---|
| 0 | clears command |
| 3 | starts command |

Fig. 1-27: Command default

**Note:** Command status can be read by writing "0" into the first element of the command parameter.

# 1.6 Error Messages

The error codes defined in the SERCOS interface specification are used. (See **SERCOS Interface specification, sec. 4.3.2.3 "Error messages in service channel**"). These codes are also used with faulty accessing of control and system parameters.

| Error code | Explanation |
|---|---|
| 0x1001 | IDN not available |
| 0x1009 | element 1 incorrectly accessed |
| 0x2001 | name not available |
| 0x2002 | name transmission too short |
| 0x2003 | name transmission too long |
| 0x2004 | name cannot be changed |
| 0x2005 | name presently write protected |
| 0x3002 | attribute transmission too short |
| 0x3003 | attribute transmission too long |
| 0x3004 | attribute cannot be changed |
| 0x3005 | attribute presently write protected |
| 0x4001 | unit not available |
| 0x4002 | unit transmission too short |
| 0x4003 | unit transmission too long |
| 0x4004 | unit cannot be changed |
| 0x4005 | unit presently write protected |
| 0x5001 | minimum input value not available |
| 0x5002 | minimum input value transmission too short |
| 0x5003 | minimum input value transmission too long |
| 0x5004 | minimum input value cannot be changed |
| 0x5005 | minimum input value presently write protected |
| 0x6001 | maximum input value not available |
| 0x6002 | maximum input value transmission too short |
| 0x6003 | maximum input value transmission too long |
| 0x6004 | maximum input value cannot be changed |
| 0x6005 | maximum input value presently write protected |
| 0x7002 | data transmission too short |
| 0x7003 | data transmission too long |
| 0x7004 | data cannot be changed |
| 0x7005 | data presently write protected |
| 0x7006 | data smaller than minimum input value |
| 0x7007 | data greater than maximum input value |
| 0x7008 | data not correct |
| 0x7009 | data password protected |

Fig. 1-28: Error specification per SERCOS

# Error with ASCII Communication

The following error messages specifically occur when communicating with an ASCII protocol!

| Error code | Explanation |
|---|---|
| 0x9001 | fatal error (symbol cannot be identified) |
| 0x9002 | parameter type error |
| 0x9003 | invalid data block number |
| 0x9004 | "Input cannot be identified" |
| 0x9005 | data element number not defined |
| 0x9006 | error in write/read (r/w) |
| 0x9007 | nonsense symbol in data |

Fig. 1-29: Error messages during ASCII communications

# Error with SIS Communication

## Error during Parameter Transmission

**status byte** If an error occurs during parameter transmission, then "error during parameter transmission" is signalled in the **status byte**.

**Error code** An **error code** is transmitted in the first two bytes of the **user data**. It describes the type of error.

The following errors can occur during parameter transmission:

| Error code | Explanation |
|---|---|
| 0x0000 | no error |
| 0x0001 | service channel not open |
| 0x0009 | element 0 incorrectly accessed |
| 0x8001 | "Service channel presently occupied (BUSY)"<br>The desired acces presently not possible as service channel is busy. |
| 0x8002 | "problem in service channel"<br>The requested drive cannot presently be accessed. |
| 0x800B | "Transmission terminated (higher priority)" |
| 0x800C | "Unallowed access (service channel not active)"<br>A new request is started before the last one is completed. |

Fig. 1-30: Error messages in serial protocol

## Execution and Protocol Acknowledgement

One **status byte** is transmitted with each reaction telegram. The status byte supplies the results of a transmission in the form of a code number.

It generally applies:

| Status byte results | Code number |
|---|---|
| transmission no error | 0x00 |
| protocol error | 0xF0 ... 0xFF |
| execution error | 0x01 ... 0xEF |

Fig. 1-31: Definition of status bytes

| Protocol error | Code Number | Error description |
|---|---|---|
| "Invalid service“ | 0xF0 | The requested service is not specified or is not supported by the addressed user. |
| "General protocol violation“ | 0xF1 | The command telegram cannot be evaluated.<br>(**Example**: wrong telegram length) |

Fig. 1-32: Definition of protocol error

| Execution error | Code Number | Error description |
|---|---|---|
| "Error during parameter transmission“ | 0x01 | An error occurred during read/write of a parmeter |
| "Error during phase transition“ | 0x02 | The specified target phase was not reached |

Fig. 1-33: Definition of execution errors

**Example:**

Write accessing a write-protected parameter **S-0-0106, Current loop proportional gain 1**:

The master is trying to write 0 to the parameter. The drive acknowledges with error message 0x7004 ("data cannot be changed").

**Command telegram:**

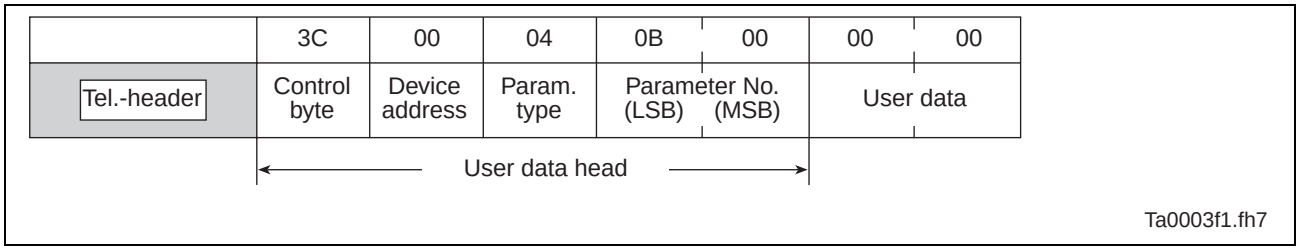


Fig. 1-34: Write S-0-0106 (Command telegram)

**Reaction telegram:**

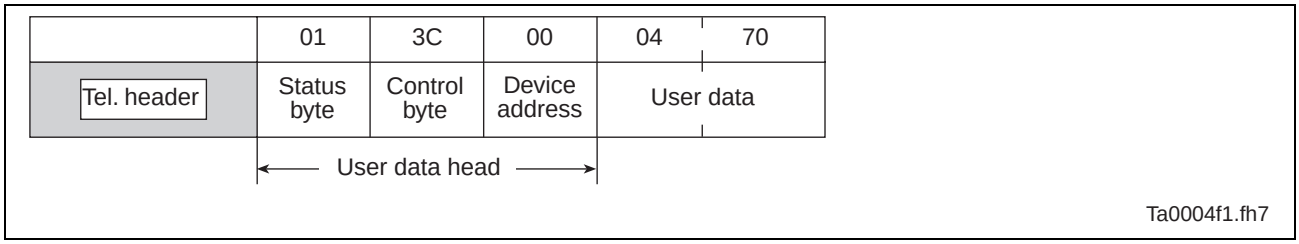


Fig. 1-35: Read S-0-0106 (Reaction telegram)

# 1.7 Application Examples (Changing Position Block Data)

## ASCII Protocol

**Suppositions:**

- Several drives are connected with a PLC via an RS485 interface. The drive address is 1.
- Drive working in positioning mode. Four positioning blocks are used.
- The target positions of the positioning blocks are to be changed via RS485 interface.

**Taking up communications with the relevant drive**

| | |
|---|---|
| **BCD:01 (CR)** | Command to switch to drive **A01:>**<br>Echo of connected drives.<br>All other drives remain passive. |

**Note:** There is no echo by symbol. Not until after the receipt of the CR does the drive send the entire input sequence back.

**Write list of target positions into drive**

The target positions of all axes are stored in the form of a list in parameter **P-0-4006, Process block target position**. To change one or more values in this list, it is necessary to write all relevant values of this list. If, therefore, four target positions are used, then all four positions must be written even if only one position is changed.

| **Drive reaction:** | | **Input:** | | |
|---|---|---|---|---|
| P-0-4006,7,w,> | | | | (CR) |
| ? | *100.0 (CR)* | target | position | block0 |
| ? | *200.0 (CR)* | target | position | block1 |
| | etc. | | | |
| ? | *<(CR)* | | | |
| *A01:>* | | | | |

# SIS Protocol

## Parameter read access (Service 0x80)

A single read acces is concluded with 1 transmission step. The master enters the following information into the command telegram:

- The desired element is selected in the **control byte** in bits 3-5 "Element". Bit 2 is set to ’1’ (last transmission).
- The unit **address** is entered.
- **Parameter type and number** are entered.
- No user data are transmitted.

The answer to a read access is put together as follows:

- The acknowledgement to a request is written in to the **status byte**.
- The **control byte** is read out of the command telegram and copied into the reaction telegram.
- The unit **address** is read out of the command telegram and copied into the reaction telegram.
- The requested data is written into the **user data**.

**Example:**

Read parameter S-0-0044 (Velocity data scaling type) out of drive with address ‘3’. The value of the parameter is 0x0042.

**Command telegram:**

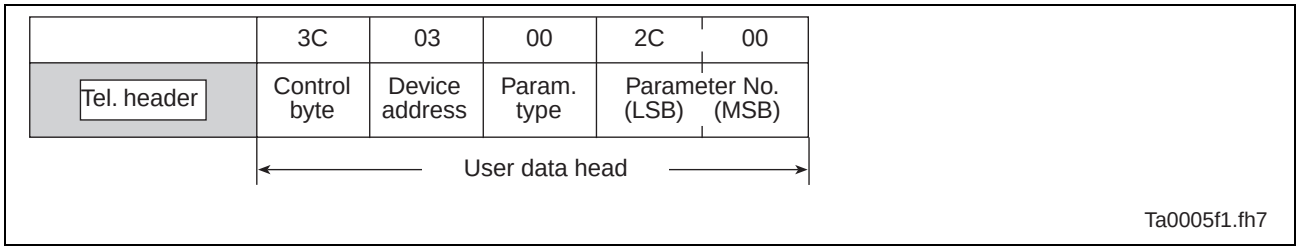


Fig. 1-36: Read S-0-0044 (Command telegram)

**Reaction telegram:**

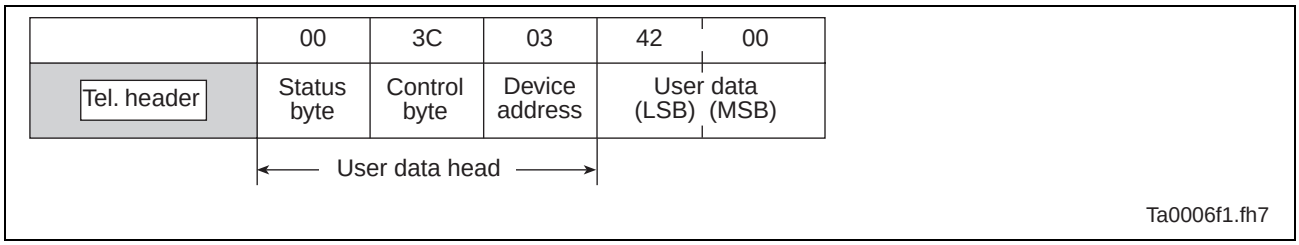


Fig. 1-37: Read S-0-0044 (Reaction telegram)

## Read acces with following telegrams (Service 0x01)

Parameters or elements with a length exceeding maximum data field length of 245 bytes are read in several steps. Bit 2 in the control byte (Reaction telegram) designates the current transmission step as either **running** or **last** transmission.

The following is the control word for a transmission in several steps.

**1st step:**

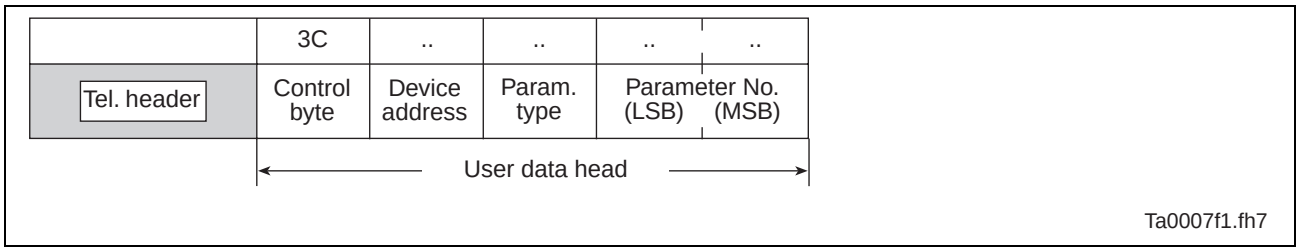


Fig. 1-38: Following command telegram 1

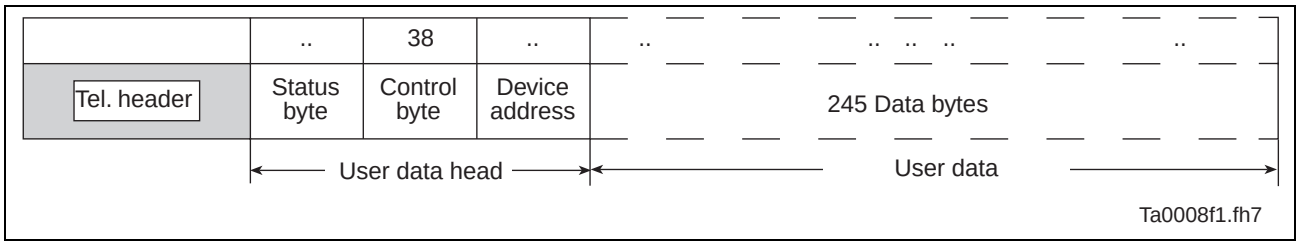


Fig. 1-39: Following command telegram 1

**2nd step:**

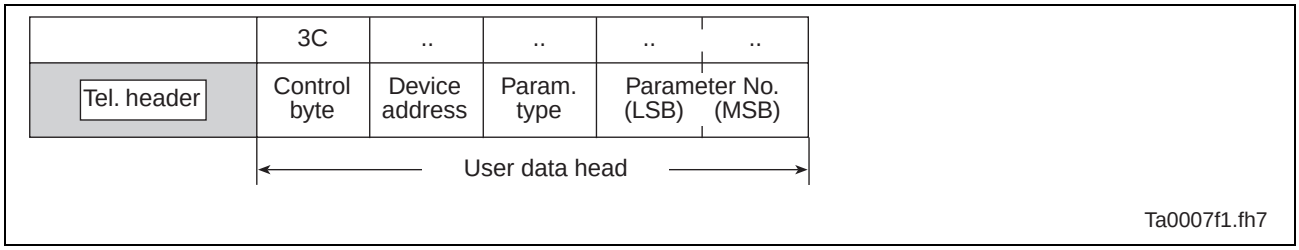


Fig. 1-40: Following command telegram 2

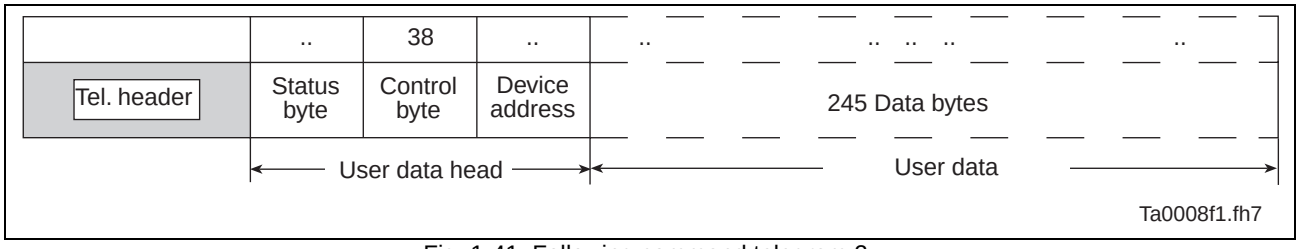


Fig. 1-41: Following command telegram 2

**Last step**

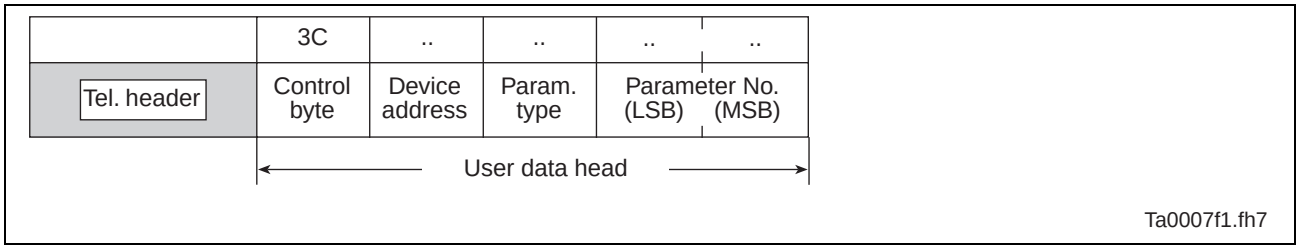


Fig. 1-42: Following command telegram 3

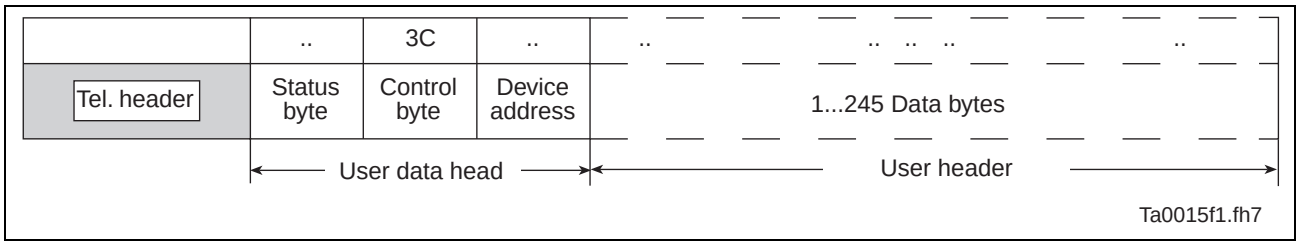


Fig. 1-43: Following command telegram 3

## Parameter Write (Service 0x8F )

A single write-access is concluded with one transmission step.

The master enters the following information into the command telegram:

- The unit address is entered.
- In the **control byte** in bits 3-5 "Element" the operating data is selected. Bit 2 is set to '1' (last transmission).
- The ID number of the parameter to be written into the **parameter number.**
- The value of the operating data is entered in the **user data**.

The response to a write accessing is put together as follows:

- The acknowledgement of a request is written into the **status byte**.
- The **control byte** is read out of the command telegram and copied into the reaction telegram.
- The unit address is rad out of the command telegram and copied into the reaction telegram.
- No **user data** are transmitted.

**Example:**

Transmit parameter S-0-0044 (Velocity data scaling type) to drive with address '3'. The value 0x0042 is written into the parameter.

**Command telegram:**

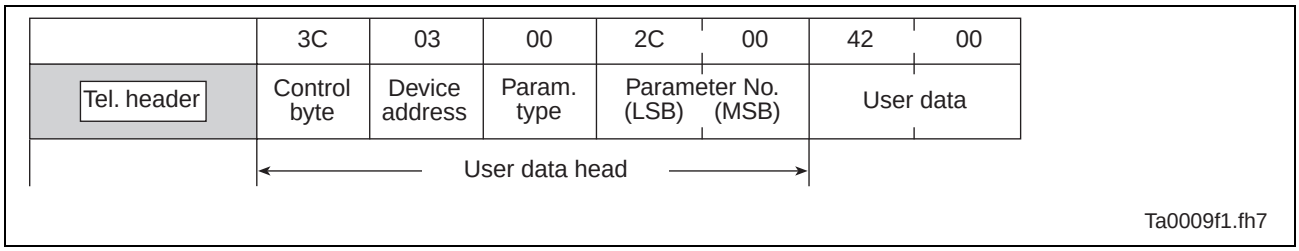


Fig. 1-44: Write parameter S-0-0044 (Command telegram)

**Reaction telegram:**

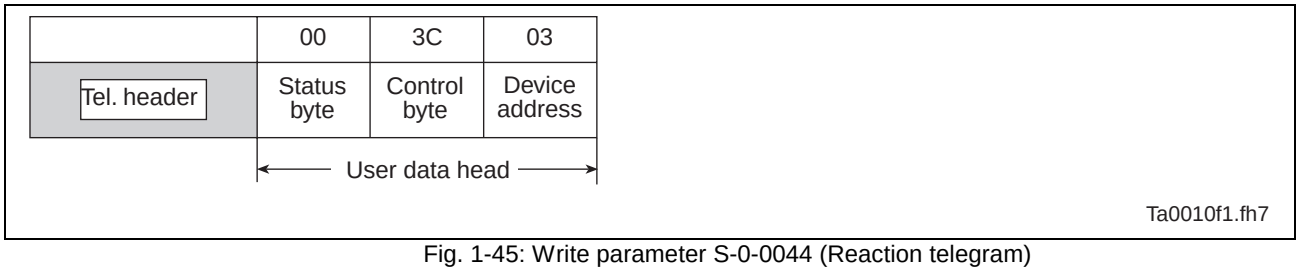


Fig. 1-45: Write parameter S-0-0044 (Reaction telegram)

## Write accessing with following telegrams (Service 0x8F)

Parameters or elements with a length exceeding **243 bytes**are read in **several steps**. A transmission of lists of this kind are performed in several steps. Bit 2 in the control byte identifies the current transmission steps as either **running of final** transmission.

The **control word for a transmission in several steps** is described below.

**1st step:**

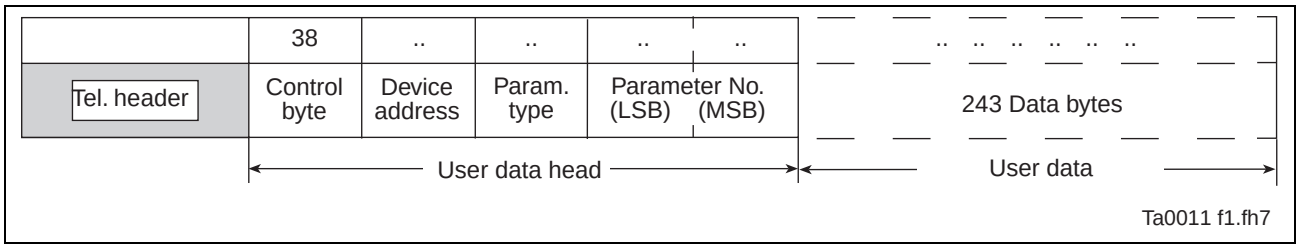


Fig. 1-46: Write following command telegram (step 1)

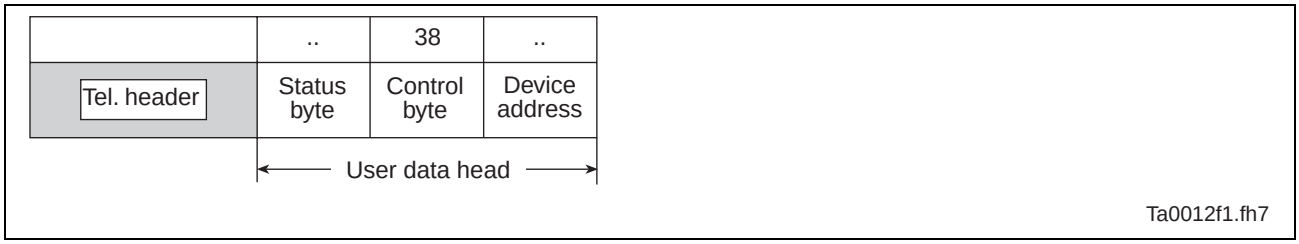


Fig. 1-47: Write following reaction telegram (step 1)

**2nd step:**

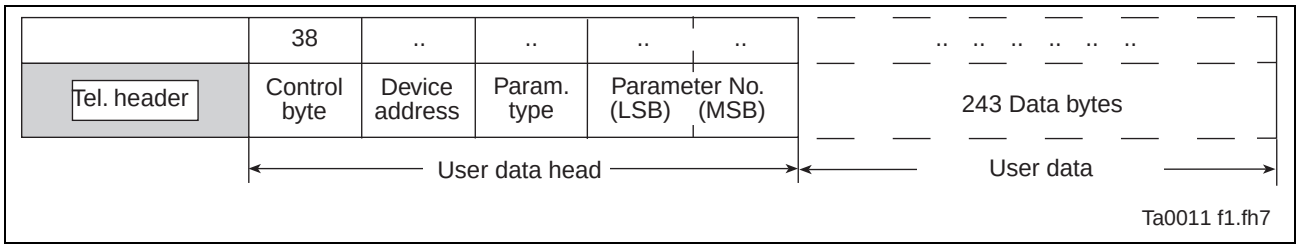


Fig. 1-48: Write following command telegram (step 2)

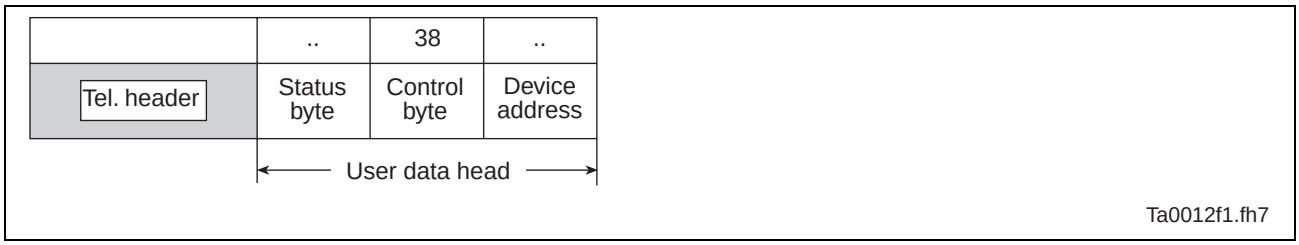


Fig. 1-49: Write following reaction telegram (step 2)

**Final step:**

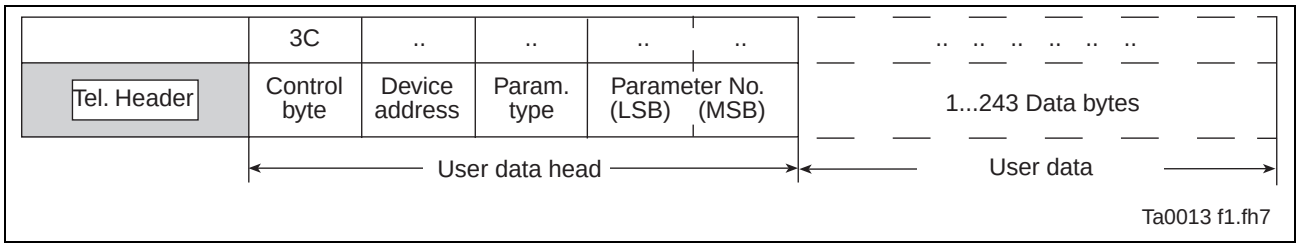


Fig. 1-50: Write with following reaction telegram (step 3)

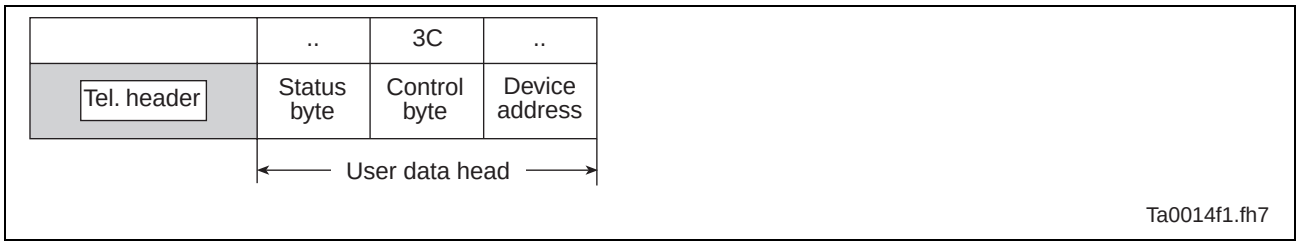


Fig. 1-51: Write with following reaction telegram (step 3)

## 1.8 Connection Techniques

See Project Planning Manual.

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# 3 Kundenbetreuungsstellen - Sales & Service Facilities

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